The Engineer

SEPTEMBER 6, 1957 28 ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

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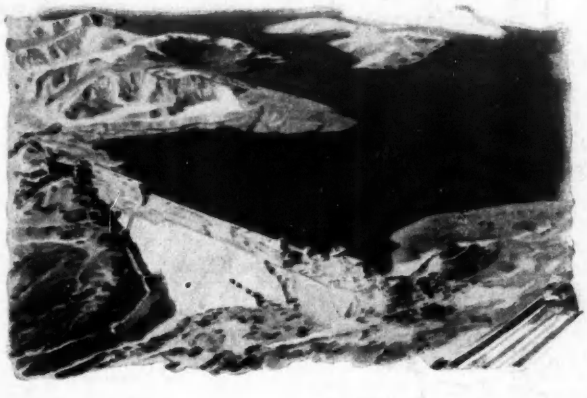
TAI LAM CHUNG WATER SCHEME, HONG KONG

Below: the reservoir



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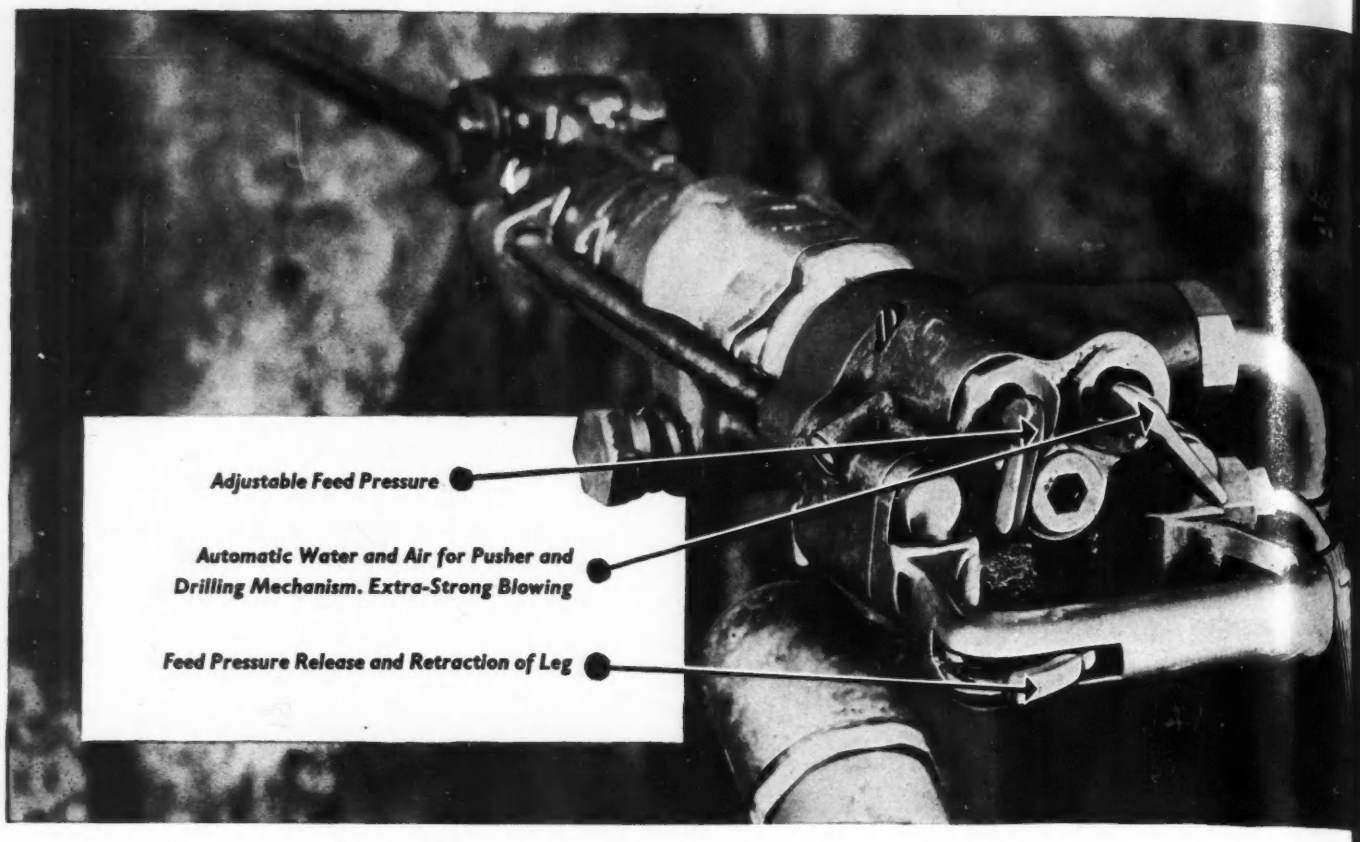
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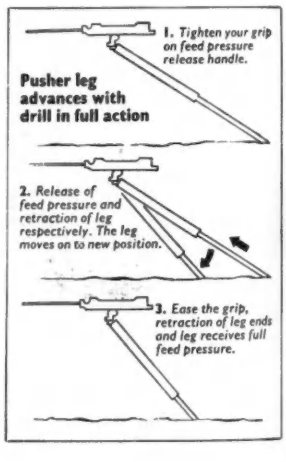
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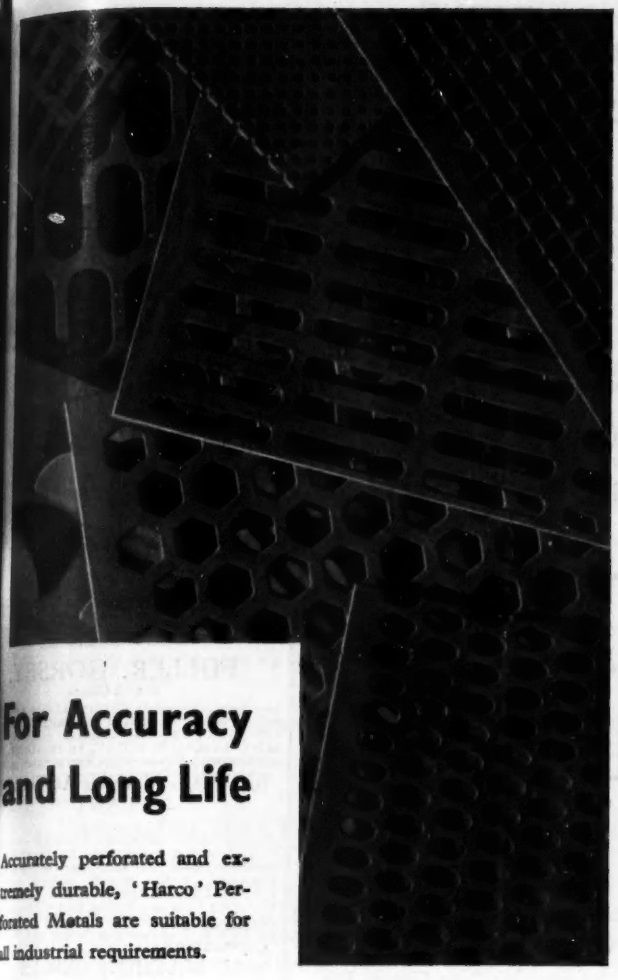

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THE ENGINEER

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THE ENGINEER

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AIRCRAFT AND WEAPONS ON SHOW

This is a small country, making little use of domestic air transport. For this reason, it can offer no real inducement to foreign manufacturers of aircraft engines and equipment to exhibit their products here, and it has, therefore, no international air display. Consequently, at the time when many readers are visiting the Society of British Aircraft Constructors' Exhibition, it is our custom to draw attention to major divergences between progress here and overseas, if they appear to be worth recalling when observing the domestic display. In the past, for example, we drew attention to the divergence in the design of high-subsonic aircraft exemplified by the "pod" mounting of engines, adopted as convenient, flexible, and readily developed elsewhere, but shunned in this country, on the basis of past experience that undercarriages, for instance, had to be retracted and not faired. In the event, the pod has been vindicated convincingly by the realisation that in compressible flow the drag is determined by a function of the size, not of the shape. But the outstanding singularity to which we have repeatedly referred has been the absence here of any supersonic research aircraft equivalent to the historic American machines of the early "X" series. This now has led logically to the state where this country appears unable to compete with other nations in the construction of advanced military aircraft. Thus, it now becomes inappropriate to compare and contrast military aircraft, since the shapes adopted overseas must often be influenced by the hope of choosing a configuration with a long future of varied applications before it. We must, of course, here refer to the private venture supersonic fighter in hand in this country. But, since the group sponsoring it shunned the opportunity to complete and fly its supersonic airframe-turbojet-rocket combination last year, it is possible that it is drawing upon the experience accumulating in building an ambitious interceptor in Canada.

Turning to civil aircraft, their prospects appeared, at the time of the 1955 Exhibition, to be assured for at least the immediate future. In fact, two months later the crippling decision was reached not to provide the Royal Air Force with a large, long range, high-speed transport. Increasingly that decision is coming to be recognised as having been strategically as well as technically and commercially an irreparable error. It may be believed that there is still a possibility of our building the second generation of the world's jet airliners, since theoretical studies suggest that a significant improvement over the machines at present building could be achieved, perhaps with ducted fans. The effort and risk involved would, of course, be large. But if our industry is not to build such an aircraft as a supersonic bomber, the prospect of its attempting a supersonic airliner can surely be regarded as wishful thinking. For the more advanced aircraft go to the fighting services for the simple reasons that those Services are prepared to risk their money and their men. It is depressingly clear that the Ministry of Supply has come to a realistic estimate of its ability to procure aircraft in the future, since it is known that research with our only vertical take-off aeroplane is being "stretched out," while the Royal Navy still waits in patience for the production of a subsonic fighter that made a catastrophic debut at Farnborough as long as five years ago.

The guided weapon is prominent at the Exhibition for the first time this year, and in view of the very great importance assigned to such weapons in the tactical plans of the future, much attention will certainly be given to those exhibited. Particularly noteworthy is one of the very few ram-jet missiles known to exist in the world. While our example is small compared to those of the country from which some of our knowledge of this deceptively simple-looking engine came, the appearance of a significantly larger duct in the display is encouraging. Some low-speed missiles which eschew the primitive form of command transmission afforded by trailing wires are also noteworthy. But while a small number of missiles have been partially freed of security, almost nothing of any significance has been said to allow any assessment to be made of the quality of their guidance mechanisms : and, because of the notorious relationship between numbers of components and reliability, it is widely believed that in a weapon system it is the guidance that is the most critical factor ruling whether the weapon will or will not prove effective in war. Thus, it is important to observe that active homing is absent. It is known not to be used in any Royal Air Force equipment, even where the guidance beam is laid visually instead of locked on, and the Royal Navy, because the

launcher itself is an integral part of the attacker's target, has good reason to accept pure beam riding. In contrast, we know that foreign beam riders use homing equipment for the final stages of the interception, and it is obvious that the very minimum of emission by the defender is optimal—there can hardly be a better target for, say, a "stand-off bomb" than a radar transmitter! The alternative technique in which the missile is self-contained is passive homing, which is regarded as having the remarkable virtue of yielding a cheap weapon which is expendable in large quantities: it is, however, difficult to credit this quality to our unusually large air-to-air missile.

A PRACTICAL UNIVERSITY OF THE ENGINEERING ART

In opening the Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia, London, on Thursday of last week Sir Christopher Hinton made what seemed at a first hearing a strange remark. Engineering, he felt, was to-day threatened by science; for it was only too easy to-day to mistake the foundation for the structure itself. Engineering, he meant, was founded upon scientific principles; but it was to be learnt fully only in engineering shops and drawing-offices. The thought led him to feel that in opening the exhibition he was opening "a practical university of the engineering art." No doubt the remark touched a responsive chord in the heart of Mr. Kenneth Bridges, the head of F. W. Bridges and Sons, Ltd., the organisers of the Exhibition. For the "Engineering and Marine" Exhibition, which has been held under a variety of titles once every two years over a space of fifty years (except when the exigencies of war prevented it) has retained from the beginning a peculiar character of its own. Indeed, we think it would not have survived and flourished had it not been built up to have that character by the late Mr. F. W. Bridges and his successors. For the modern trend in exhibitions in this country is all towards specialisation, whereas the Engineering and Marine Exhibition never has been specialised, even though it is still far from representative of all the products of the whole of Britain's engineering industries. It seems illogical that it should flourish when other similarly unspecialised exhibitions like, for example, the engineering section of the British Industries Fair have been going downhill. The illogicality is made to appear the more extreme in that quite a number of specialist exhibitions, now regularly held, owe their birth to the "Engineering and Marine," at which they tried their fledgeling wings as specialised sections, before taking flight to become self-supporting.

Why does the Engineering and Marine Exhibition continue to flourish while other general exhibitions have declined in importance? Of course, more than one factor is at work. The Exhibition has an advantage in that it is held in London. That statement may be distasteful to those who live in other great industrial cities in this country, but we do not think it can be gainsaid. That the Exhibition is held at the beginning of September is, too, we believe, an advantage. We shall dilate upon that point presently. But the overriding factor is that the Exhibition is so organised that it is distinctively different from a trade fair. Certainly those firms which take space to exhibit their goods hope and expect to do good business; and the organisers would not be doing their job if they did not make the way smooth for buyers from all over the world to reach Olympia. But the word "Exhibition" is truly used of the "Engineering and Marine." Business is in reality subsidiary to the job of exhibiting firms' products to engineers. The affair is more social and technical than commercial. Engineers visit the Exhibition quite irrespective of whether they intend to buy. They go to meet the friends and acquaintances they can confidently expect to find there and they go to find out what is going on in engineering, what advances have been made in engineering practice, and what new products have been devised. There is much more technical discussion upon each firm's stand about the firm's products—and those of other firms—than negotiation of contracts or answering of business inquiries. Any engineering exhibition, of course, has something of this flavour. But the organisers of the "Engineering and Marine" set out from the beginning to emphasise this social and technical characteristic. Numbers of eminent engineers are flattered by being made "patrons" of the Exhibition. Numerous institutions, associations and societies are approached to fix upon particular days when their members can expect other members to be present. Visits by parties and groups from individual works are especially welcomed. The social rather than the business nature of the Exhibition is stressed at the inaugural luncheon. The Exhibition is held in the early days of September. Holidays are then almost over. But the regular meetings of societies have not begun, while summer meetings, conferences and symposia are all for the most part over. Engineers are ready to pick up again their social contacts and, back from holidays, are eager to talk technicalities once more. Sir Christopher could thus rightly refer to the Exhibition as a "practical university of the engineering art." That is what it is; that is why it survives and flourishes. Paradoxically the better the exhibition serves as a means of spreading engineering knowledge and as a means of bringing engineers together in fruitful discussion, the more valuable it proves as a place of doing business. Fifty years ago the late Mr. F. W. Bridges perceived that the paradox might prove true. Experience has proved him right.

KITE FLYING

The hazards to which overhead power lines are prone are, we realise, distressingly numerous. They are quite often struck by lightning; they can suffer corona discharge; they can be afflicted by industrial deposits and irked by flash-over, and they can be brought down by accumulations of ice and snow. Their towers can even be toppled over by the sledge-hammers of infuriated farmers! Having recently watched thousands of martins and swallows perched, with delicious impunity, upon a short length of cable we can even believe their weight constitutes a hazard, too. We remember once in the back cast hitching our fly on to a power line, when fishing for trout. But the hazard there, we discovered, was rather to the gut than to the line. Often we have seen that children's toy, a bit of stuff with a weight attached, to act as a parachute, draped over a cable, and once—we have no clue as to how it got there—a brilliantly coloured male shirt. Whether those objects constitute hazards we do not know. But kites! Until a circular from the South Western Electricity Board brought the matter to our notice it had never occurred to us that kites could constitute a hazard. Nor, for that matter, had it ever occurred to us to fly a kite close to a power line. Apparently, if entangled in the lines, a kite can cause "interruptions in electrical supplies to local residents." One bold parent, it is reported, even attempted to pull a kite clear of a high-voltage line, "but fortunately he escaped injury." Presumably the line escaped injury, too, even though it can hardly have been designed to withstand the hazard of a man hauling away at it with all his strength. "In the event of a kite fouling a line," we are informed, "the Board's local office should be notified at once." But that means both going to the trouble of finding the local office and thereafter making abject confession of the "crime." This seems to ask rather much. Most parents in such embarrassing circumstances will, we fancy, prefer to walk away as quickly as possible (with all the dignity they can muster) trying to pretend not to notice. Subsequently childish tears can be stemmed by the purchase either of a new kite or, if too impoverished, a lollipop. For, as the Board solemnly states, "it is dangerous for an unqualified person to attempt to pull the kite clear." But, as it is obvious that not all parents appreciate that point, it might be worth affixing to transmission line towers in places peculiarly liable to the kite hazard the notice which is reported (apocryphally) to have been seen on such towers in Ireland. "To Touch these Wires means Death. Offenders will be Prosecuted."

A Seven Day Journal

Opening of the Engineering and Marine Exhibition

On Thursday of last week a luncheon was held at Olympia, London, to mark the opening on that day of the Engineering, Marine, Welding and Nuclear Energy Exhibition. The Chairman, Mr. W. K. G. Allen, this year's president of the exhibition, in welcoming the guests, remarked that the first exhibition in the series was held fifty years ago and that this exhibition was the twenty-first of the series. This year, for the first time, nuclear energy appeared in the Exhibition's title and this, he felt, was the appropriate exhibition at which nuclear engineering exhibits should be displayed. It was particularly appropriate that their chief guest was Sir Christopher Hinton, who had made such a massive contribution in the nuclear field.

In reply, Sir Christopher said he hoped they had in nuclear engineering recaptured something of that Victorian enterprise which had made this country great in the nineteenth century. The Victorians achieved a balance between theory and practice because they combined a grasp of scientific principles with an understanding of practical possibilities. In the Atomic Energy Authority they had aimed at a similar balance. They took as their objective that they should be successful rather than clever. They sought to apply well-established techniques to new problems with daring but with reliability. As a direct consequence, Calder Hall station was the dullest of places in which to work because nothing ever happened! Under the 1955 White Paper there were to be 1800MW of nuclear power capacity installed by 1965. Since then the target had been revised up to 5000MW or 6000MW. But it would be wrong to suppose that the number of stations would be correspondingly increased, since the size of plant had been greatly increased beyond what was regarded as practicable in 1955. Speaking of the consortia of firms which have been created in this country for the construction of nuclear power plants, he doubted whether more than the five existing ones were needed, as a greater number would be inconsistent with the number of stations to be built, even though it had to be remembered that by 1965 the bulk of power plant construction for this country would be of nuclear stations. He thought it inconceivable that the existing consortia would be able to fabricate and construct all these stations using only the resources of member firms. Sub-contracts would have to be placed with other firms in the usual way. Similarly he felt that countries abroad would not be prepared indefinitely to buy reactors and components from this country. But we ought to be able to license designs in overseas countries and sell specialised components. By doing so we ought to be able to keep well ahead of the world.

International Conditions of Contract for Civil Engineering

For two years, negotiations have been in progress between the Federation Internationale des Ingenieurs-Conseils and the Federation Internationale du Batiment et des Travaux Publics with the aim of drawing up the conditions for a standard form of contract for civil engineering works which are open to international tender. An agreement has now been signed, which is considered to hold an equitable balance between employers and contractors, and so a standard set of conditions can now be applied to international contracts, in much the same way as is done with the standard conditions of contracts in this country. The agreement was signed on August 29, in Zurich, by Mr. J. S. Tritton, president of the Consultants' International Federation, and by Mr. Norman Longley, president of the international contractors' organisation. The consultants' organisation, F.I.D.I.C., has membership in ten European countries, and the contractors' organisation, F.I.B.T.P., has membership in the same ten countries and also in four further European countries and in Canada and the Argentine.

The idea behind these conditions of international contract is to give a clear and logical sequence of clauses, without ambiguity, and to eliminate as far as possible any speculative elements. Also, the risks inherent in civil engineering construction have been distributed fairly, according to the clauses, as between the employer and the contractor. An interesting point relates to the settlement of disputes by an independent arbitrator, using the procedure of the court of arbitration of the International Chamber of Commerce. It is stipulated, however, that pending completion of the work, the engineer's decision is final, and there shall be no delay in its execution on that account. The agreed form of contract has been prepared in English, but translations into French and German are being made.

The Engineer
100 Years Ago

(SEPTEMBER 4, 1857)

"The Main Drainage of London"

"The land drainage of the valley of the Thames from Richmond to the Nore is the first work to be done, and as this work should have been executed before a single foundation for the capital was dug, it should still be finished as if a single building did not exist. The soundness of this maxim is manifest, for the work to be done in Lambeth and Westminster marshes is similar to that to be done in those of Plumstead and Essex.

"Now, from the marshes being below highwater level, there is only one course left to pursue as to their drainage, viz., two large main drains, one on each side of the river, and the pumping of the water at the outfall; and as the area of land which would thus have to be drained is larger, the size of the sewers would also have to be large to remove storm water; and, further, to meet any emergency which might occur in the house drainage, the two main drains ought to be of a size sufficient to remove all the sewage of the capital also. This would seldom have to be done; but it would be wise to make such a provision. No doubt some parsimonious citizen may grumble at the increase of expense thus involved, but too much has been said about expenses and too little about properly performed work, for capital invested in properly executed land drainage would return ample interest; and as capital properly invested in house drainage will do the same, and as the one investment increases the value of the other, the two put together will cover the extra expense incurred by increasing the size of the main drains, so as to give them capacity for the removal of the sewage in an emergency, as during the thaw of heavy falls of snow in winter."

Atomic Energy Appointment

It has been announced this week that, following the appointment of Sir Christopher Hinton, F.R.S., as chairman of the Central Electricity Generating Board, Sir Leonard Owen, at present director of engineering and deputy to the managing director of the industrial group of the United Kingdom Atomic Energy Authority, has been appointed managing director of the industrial group. Sir Leonard Owen, who is sixty, was created a Knight in January. He has been engaged in the development of Britain's atomic energy programme since 1946, when he was appointed director of engineering on the production side by the Minister of Supply. In the following year he became assistant controller in the Atomic Energy Division's production side. When the United Kingdom Atomic Energy Authority was formed in 1954, his title became director of engineering and deputy managing director.

Sir Leonard was educated at Liverpool Collegiate School and Liverpool University, where he obtained his degree of Master of Engineering. During the first world war he was with the 6th King's Liverpool Regiment, and afterwards was successively with Brunner Mond and Co. and I.C.I. Alkali, Ltd., with whom he was engaged in the engineering department, designing new chemical plant and additions to existing chemical plant. From 1940–1945 he was on loan to the Ministry of Supply as Director of the Royal Filling Factories. Sir Leonard is a member of the council of the Institution of Civil Engineers, a member of the Institution of Mechanical Engineers, and a member of the Institution of Chemical Engineers.

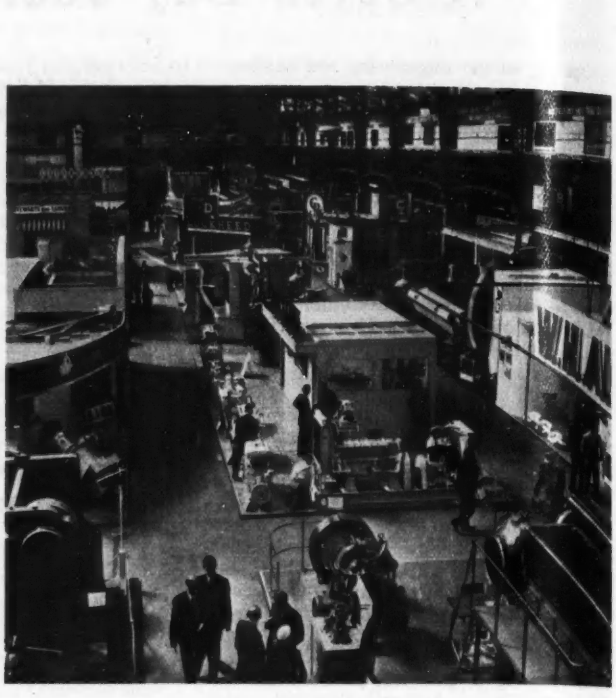
National Institute of Agricultural Engineering

The National Institute of Agricultural Engineering has just issued a report which deals with its work in the year ended September 30, 1956. The Institute's headquarters are at Wrest Park, Silsoe, Bedfordshire, and there is also a Scottish station at Howden. Mr. W. H. Cashmore is the director of the Institute, and the work is carried out in six main departments, namely, agricultural testing, field investigation, grain, horticultural engineering, mechanical engineering, and soil.

The report surveys the principal activities of each of these departments. During the year, it is stated, the demand for the testing of agricultural implements was not only maintained, but was somewhat in excess of the capacity of the staff available. One section of the testing department is now engaged in the "mechanisation" of testing by evolving rigs and special measuring apparatus to enable more varied and more accurate measurements to be taken. In the mechanical engineering department, where tractors and driers are tested, the scope of tractor testing has been increased to cover tropical conditions, and a high-temperature room and a dust chamber are now installed. It is not possible to find natural dusty conditions in this country, comparable with many countries overseas, and the dust chamber tests are proving very valuable for improving air cleaning systems, and the general design of tractors to prevent high depreciation from dust. Further consideration, the report notes, has been given to the application of hydraulic transmission to agriculture (see The Engineer, April 27, 1956). A recent example is the development of a two-row mounted potato harvester working at speeds of ¼ to ¾ m.p.h.

ENGINEERING AND MARINE EXHIBITION

The Engineering, Marine, Welding and Nuclear Energy Exhibition at Olympia, to give it its full title, was opened on Thursday of last week. It is the twenty-first of the series and it is just fifty years since the first was held. The interest the exhibition arouses around the world was indicated by the fact that no less than fourteen ambassadors attended the inaugural luncheon and that there were guests from almost every part of the world. In a speech he made at the luncheon held at Olympia on the opening day, Sir Christopher Hinton referred to the Exhibition as a "practical university of the engineering art." The organisers can well claim it to be an apt description. For the Engineering and Marine Exhibition has become nearly unique in this country, as our accounts of the exhibits demonstrate, in being not a specialised trade show but a general engineering exhibition.



Quasi-Arc, Ltd.

A welding gantry developed for shipyard use in making simultaneous fillet welds on either side of bulkhead stiffeners is shown by Quasi-Arc, Ltd., Bilston, Staffs. The machine is operated by two men and is self-contained with its ancillary equipment mounted on it.

The equipment (Fig. 45) comprises a travelling gantry which carries two automatic welding heads, two recirculating powder recovery systems and two welding current power units. In its latest form the machine runs on rails at 60ft centres and spans 50ft of working area, the clearance between the top of the rails and the underside of the beam being about 7ft. The complete gantry traverses along these rails set in the shop floor at welding speeds smoothly variable between 6in and 50in per minute. Because welding is done in one direction only, a high-speed traverse of 50ft is provided to return the gantry to the starting position after the completion of each weld.

Two standard "Unionmelt D.S." welding heads are mounted on a carriage, which can be traversed manually along the gantry to enable the welding heads to be positioned over each stiffener in turn. In addition, the carriage serves as a control cabin for one of the two operators. The carriage also supports the two melt recovery units, two 150 lb rod reels and an electric hoist for lifting the coils of wire on to the reels. There is a platform at each end of the gantry ; one carries an a.c. transformer, the other a d.c. rectifier.

Fig. 45—Welding gantry for twin fillet welding of bulkhead stiffeners—Quasi-Arc

The company has also introduced a new internal welding boom (Fig. 46), for welding the internal longitudinal seams in small-diameter pipes, and it incorporates closed-circuit television equipment for guiding the welding head. This equipment can be used for pipes up to 28ft in length. It consists of a tubular steel boom, fitted to a fabricated steel support structure. The boom has 6in vertical adjustment by means of a handwheel-operated lead screw, an adjustment which is required to cater for various plate thicknesses, and the height of the bottom of the pipe from ground level. A "Unionmelt D.S.H." welding head, suitable for parallel electrode welding, is fixed to the end of the boom, and an angle control sector is provided for positioning the electrode in relation to the seam. A continuously rated melt recovery unit is incorporated for reclaiming unfused powder.

Close to the welding nozzle at the end of the boom is a television camera and a 150W photo-flood lamp, on a universal mounting bracket. The camera provides a picture of the welding nozzle pointer in relation to the seam. If the pointer moves off the seam, the deviation can be seen on the television screen and adjustment can be made to ensure that the weld is deposited in the correct place. The operator's control desk (Fig. 47) consists of a television camera control unit, a monitor 14in screen and a control panel for the welding head and roller beds, all mounted in a sheet metal casing. This equipment is powered by a "MRA.1200 U." rectifier unit continuously rated at 1200A.

A special hopper of 50 lb capacity is supplied for the carrying of "Unionmelt"

flux. During welding, the end of the boom is supported by twin spherical support rolls, which ride on the inside of the pipe and ensure maximum rigidity at the welding point. Twin 150 lb wire reels are fixed to the support structure at the end of the boom. The boom is used in conjunction with a traversing roller bed, designed to accommodate pipe with internal diameters from 17½in to 50in capable of traversing the pipe at infinitely variable speeds between 15in and 90in per minute, and for quick traverse in both directions at 20ft per minute.

A new motor generator has been added to the Quasi-Arc range of manual welding equipment. It is known as the "MGB 400" (Fig. 48), and it is designed to combine robust construction with easy manœuvrability. It is intended for depositing electrodes (most of which fall in the AWS/ASTM classification E.6010 or the B.S. classification E.110) frequently used in positional pipe welding. The set gives stable arc conditions when used with the new Quasi-Arc "Celtian" electrodes for pipe welding. The main particulars of the "MGB 400" are maximum current, 400A; maximum continuous current, 300A; continuous test current, 210A; minimum open circuit voltage, 55V; maximum open circuit voltage, 95V; speed, 1500 r.p.m.; weight without undergear, 9¾ cwt, with undergear 10 cwt; overall dimensions, with undergear, 3ft 6½in by 2ft 1½in by 3ft 6in high. The set is designed to comply with B.S. 638 : 1954, with special emphasis on rapid voltage recovery. Separate excitation by means of a transformer and metal rectifier is used, with the object of reducing maintenance. Improved brushgear is used to allow rapid adjustment to spring tension and brush withdrawal; the large brush area is designed to ensure sparkless commutation on all loads.

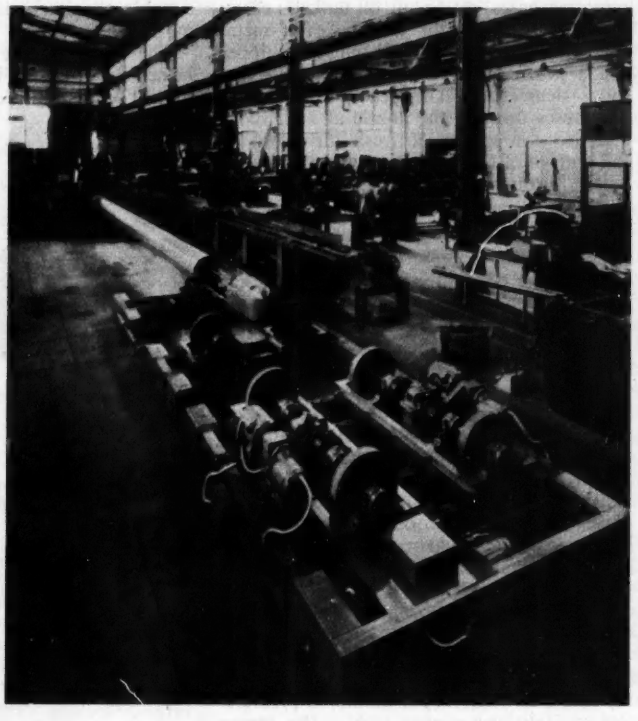


Fig. 46—Internal seam welding boom fitted with television equipment for guiding the weldhead inside small diameter pipes—Quasi-Arc

The rotor of the motor and the generator armature are mounted on the same shaft, which is supported at each end by a large ball race fitted with a grease nipple.

The end shields are of "Fibreglass," and are easily removable to allow access to the generator brushgear and motor. Starting is simplified by the use of an automatic star-delta starter. When the operator pushes a button, the remainder of the starting operation takes place automatically. The method of current and open circuit voltage regulation developed for this equipment ensures that the current selector switch cannot be left at mid-point between any two of its correct positions. The system also enables the operator to adjust the volt/ampere characteristic of the equipment, so that welding conditions can be varied to suit exactly the work in hand. The set has facilities for single-point lifting, and among the optional extras which can be supplied are an ammeter and voltmeter and a steerable four-wheeled undergear, as illustrated.

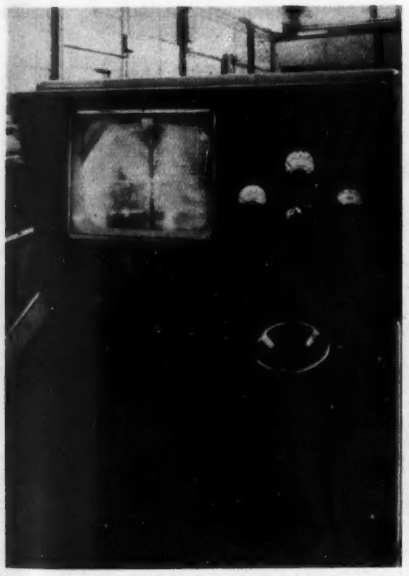


Fig. 47—Control cabinet and television screen showing the welding arc on internal longitudinal seams in pipes—Quasi-Arc

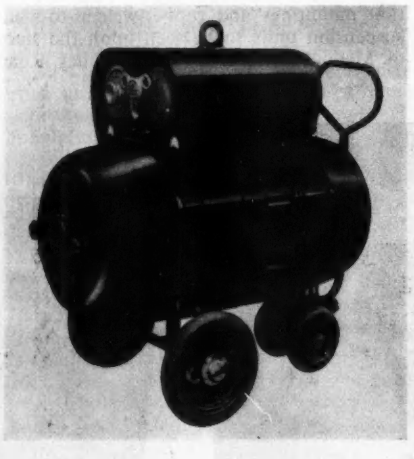


Fig. 48—Welding motor generator set "MGB 400" designed for depositing pipe welding electrodes. Maximum welding current 400A—Quasi-Arc

Gilbert, Gilkes and Gordon, Ltd.

The principal exhibit of Gilbert, Gilkes and Gordon, Ltd., of Kendal, is a working model which demonstrates the variety of hydraulic services which can be provided on a small ship by the "GGG" heavy-duty, self-priming pump, which has been made by the firm for many years. For demonstration purposes the model provides power for a small hydraulic winch, a bilge ejector and a deckwash and fire hose.

The winch, powered through a hose line or fire main supplied by the pump, is a small pelton wheel driven unit. According to the hydraulic supply pressure it is capable of handling loads from 100 lb to 500 lb. It is essentially simple in design, with a vertical shaft pelton wheel in the base being driven by a jet of water from a hose connection in the base.

A worm reduction unit above the pelton wheel has its output shaft extended at each end to take the 6in drums of the winch. The pull and hauling speed of the winch is dependent upon the pressure of water and the speed in operation is normally controlled by the load on the drums. The heavier the load, the slower the drum speed.

A somewhat similar form of construction, using a pelton wheel driven by water from a general service or other pressure water line, is fitted on a line hauler which the firm has developed for single-line fishing vessels.

Cathodic Corrosion Control, Ltd.

Lead alloy anodes developed for impressed current cathodic protection of metals subject to corrosion from sea water are shown by Cathodic Corrosion Control, Ltd., Duncan House, Dolphin Square, London, S.W.1. These lead alloy "CX3" anodes, as they are called, operate with from 2A per square foot to 30A per square foot and at a maximum efficiency between 5A and 15A per square foot, and they are stated to have proved very effective in sea water or water where resistivity is below 1000 ohm/per centimetre.

The anodes are supplied in the form of castings, lines and ribbons. The three standard forms of cast iron weights of 1½ lb, 5 lb and 30 lb, giving a range of current output from ½A for the smallest to 15A for the largest anode. Line anode is made in lengths up to 300ft in the form of an extrusion 1½in diameter about a concentric copper core. In sea water this line anode has a current output of about 3A per foot run, and it is suitable for vertical suspension in lengths up to 100ft from a single support.

The ribbon anode has been developed for marine applications, particularly for use on ships' hulls. In this case the alloy is extruded over a copper conductor and mounted in a plastic former designed to give a flush overall anode on the side of the vessel. The whole anode is attached to the hull by a series of plastic-stranded steel straps secured by stud-welded bolts. The output of ribbon anodes varies from 250mA to 1½A per foot.

Bolinders Company, Ltd.

On its stand the Bolinders Company, Ltd., 4, Lloyds Avenue, London, E.C.3, shows products manufactured by A. B. Götaverken and Nydquist and Holm Aktiebolag of Sweden. The Götaverken exhibits include, besides models of ships fitted with this mark of engine, such as the Swedish liner "Gripsholm," a working model of an engine which is representative of the range manufactured and covers powers from 1850 to 15,000 b.h.p. The engine, of which the model is shown, is the company's mark D.M 630/1300 engine, having eight cylinders, which is turbo-charged, has a bore and stroke of 630mm and 1300mm respectively and develops 6650 b.h.p. at 125 r.p.m., based on a mean indicated pressure of 125 lb per square inch. This single-acting two-stroke unit has two fuel valves per cylinder, oil-cooled pistons, fresh-water-cooled cylinders, and a welded bedplate and entablatures with cast iron guides. The box pattern entablatures transmit the ignition forces from the cylinder top to the bedplate, using through stay bolts. A constant pressure system is used in the supercharged engine and the power per cylinder is 1250 b.h.p. The turbo-charger is exhaust-gas-driven and the centrifugal compressor is placed before the reciprocating scavenging pumps; before reaching them the air, which is raised in pressure and temperature, passes through an intercooler. An exhaust gas receiver equalises the pressure fluctuations before the gas enters the turbine.

Also on the stand is a model of a Polar naturally-aspirated marine diesel engine, MN 16, having six cylinders of 340mm bore by 570mm stroke, and able to develop 1140 b.h.p. at 300 r.p.m. and a brake mean effective pressure of 5·5 kg per square centimetre. In addition there is a supercharged engine, of the same mark, arranged for demonstration running and manœuvring and illustrated on this page (Fig. 49). This is a two cycle, single-acting, trunk piston engine of simple and robust construction having hard wearing cast iron cylinder liners, a semi-built forged crankshaft and cast iron oil-cooled pistons. The engine has pilot injection fuel system and is fitted with the company's quick manœuvring device. Two Napier turbo-chargers are fitted and raise the output of the naturally aspirated engine by 30 per cent so that the MN16S engine develops 1640 b.h.p. at 335 r.p.m. The MN engines are built with four to ten cylinders, covering a range of power from 760 to 1900 b.h.p. at 300 r.p.m., of which the six and nine-cylinder units are available in supercharged form.

Also to be seen on the stand are two Götaverken tank ventilators for removing explosive gases left in an oil tanker's cargo tanks. The ventilator consists of a metal trunk, about 5ft in length, having at its upper end a nozzle which can be coupled to the ship's steam line. The steam, when turned on, passes through the nozzle at high speed and draws a stream of fresh air down to the bottom of the tank from where it rises to escape through open hatches, bringing with it the gases.

Sir George Godfrey and Partners, Ltd.

A number of examples of the Roots design positive displacement superchargers, compressors, boosters, blowers and vacuum pumps made by Sir George Godfrey and Partners, Ltd., of Hanworth, Middlesex, give some impression of the many applications of this firm's products. A typical example of this form of construction can be seen in the photograph reproduced in Fig. 50, which shows one of the firm's "MU–2000" universal blowers with the casing cut away to reveal the helical rotors. The rotor shafts are fitted with special seals to prevent lubricating oil entering the rotor chamber to pollute the air or gas being handled. These seals also minimise the escape of explosive or contaminating gases from the rotor chamber into the end casings of the blower. This form of blower is designed for flows up to 1650 cubic feet per minute at pressures up to 10 lb per square inch. The largest machine in the range is designed for flows up to 3400 cubic feet per minute at 10 lb per square inch pressure, and a motor-driven unit is exhibited.

A mobile pneumatic conveying plant for granular materials is shown. It is fitted with two of the firm's blowers. One of the units is employed as a blower for the cyclone of the plant and the other is used to induce vacuum suction from the cyclone.

Metalastik, Ltd.

The many interesting forms of anti-vibration mountings and rubber-welded-to-metal suspension units to be seen upon the stand of Metalastik, Ltd., Evington Valley Road, Leicester, includes the new "Cushymount" engine mounting originally developed for a group of diesel-electric locomotives being built for the C.I.E. by the Metropolitan-Vickers Electrical Company, Ltd. These engine mountings are so designed that, without alteration in size, they can be arranged with suitable characteristics for most diesel locomotive engines.

The construction of the new mounting can be seen in Fig. 51; it is located in the locomotive frame by a spigot in the base and

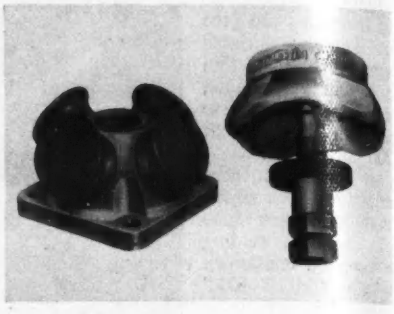


Fig. 51—Anti-vibration mounting for engine mounting in diesel-electric locomotives—Metalastik

secured by four bolts. This base casting is in the form of a pyramid and it has four faces on each of which there is a circular rubber-bonded-to-metal "element." These elements are designed to give the same flexibility in all directions and are loaded in shear and compression to provide high load capacity and large deflection. The cup-shaped top casting to which the engine foot is attached by four screws protects the elements from the effects of oil and mechanical damage. By preloading the rubber springs during assembly the performance can be increased. An adjustable rubber-covered buffer incorporated in the mounting is stated to enable vertical deflection to be kept to within ±0·125in of the mean loaded position. Horizontal movements are limited when the centre bolt of the mounting comes into contact with an impregnated asbestos ring fitted into the neck of the base casting.

By changing the rubber elements, which are made with or without interleaves and in varying hardnesses of rubber, various load/deflection characteristics can be obtained

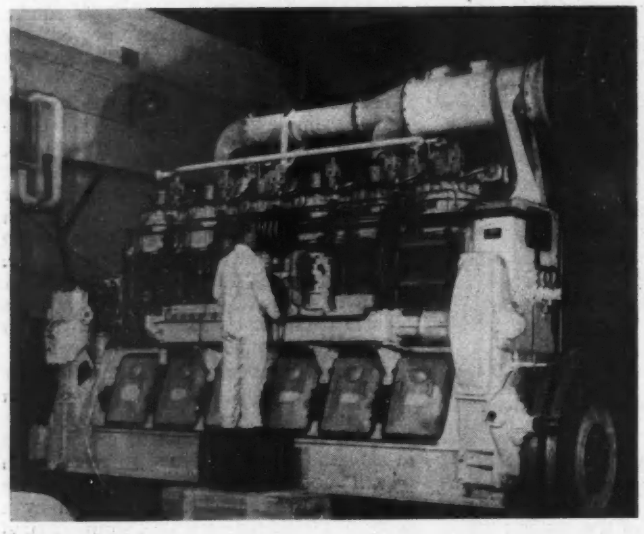


Fig. 49—Mk. MN16S two-stroke, single-acting, six-cylinder supercharged engine—Bolinders

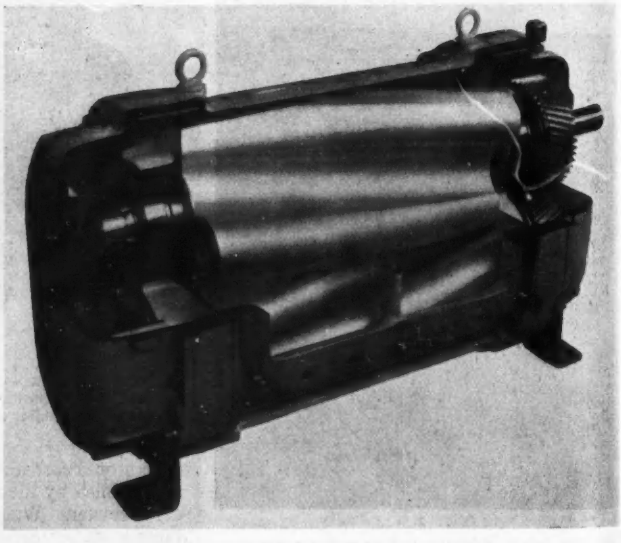


Fig. 50—Universal blower for flows up to 1650 c.f.m. at discharge pressures up to 10 lb per square inch—Godfrey

from one size of mounting. The "Cushy-mounts" supplied to Metropolitan-Vickers can be made stiff enough for a deflection of $\frac{1}{16}$in under $5\frac{1}{2}$ tons, or sufficiently flexible to deflect $\frac{1}{16}$in under 1·3 tons. A deflection of $\frac{1}{16}$in is stated to give excellent vibration insulation for frequencies as low as 500 c.p.m. A slightly larger version of the mounting, which is being used for large Crossley diesel generating sets at Dounreay Atomic Energy Establishment and for other applications, gives a deflection up to $\frac{1}{4}$in for a load range of 1 to 5 tons.

J. H. Carruthers, Ltd.

The range of reciprocating cargo oil pumps for tankers made by J. H. Carruthers, Ltd., Polmadie Works, Glasgow, S.2, has been extended by the introduction of a series of marine centrifugal pumps for both cargo and engine-room service. Two of the three engine-room centrifugal pumps exhibited incorporate a new system of priming developed by the firm. A two-stage vertical pump of this new "Flowmaster" range, shown in Fig. 52, is arranged for self-priming.

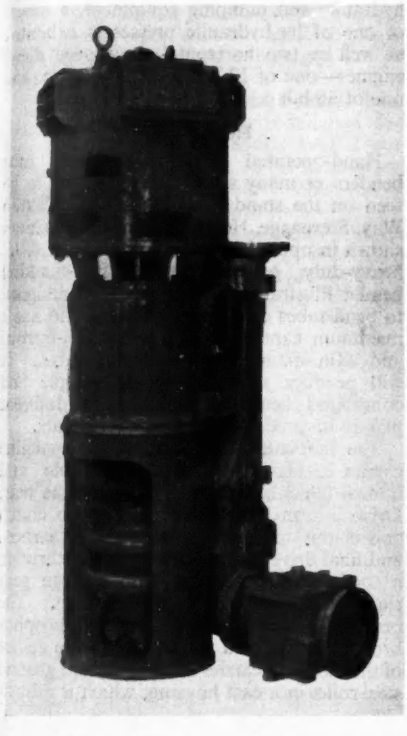


Fig. 52—Self-priming, split-casing, two-stage centrifugal pump for marine engine-room service—Carruthers

This vertical split-casing centrifugal pump has a front half and a back half cover, the back section of which incorporates the ports and passages for the entry and discharge of the liquid. The pump is driven through a Hardy Spicer shaft and coupling assembly by the motor. The main framing of the pump assembly incorporates a priming tank in the rear. The impeller which is fitted is of special design, with a conventional main impeller on the lower side and an auxiliary vane system on the upper side. A reservoir of liquid is maintained at all times in the priming tank and this liquid is fed by gravity into the priming impeller. For self-priming purposes fluid fed into the priming impeller is accelerated and thrown into the main pump casing and on through the discharge pipe back into the reservoir. This serves to create a vacuum by which fluid is drawn up the suction pipe and into the eye of the main impeller. The main impeller then starts to pump and the increased discharge at a high velocity closes a reflex control valve, which isolates the water in the priming tank.

Photographs of some of the cranes made by the firm which are shown upon the stand include one of a charge face crane for the Dounreay reactor sphere. This "Goliath" crane, of welded plate box construction, operates on an 80ft diameter circular track, and the main girder carries two crabs of 25 tons and of $7\frac{1}{2}$ tons capacity. The "Microsem" creeping control system fitted to the hoisting units of the crane facilitate precise handling and positioning of loads.

Murex Welding Processes, Ltd.

An automatic arc welding equipment has been specially developed by Murex Welding Processes, Ltd., Waltham Cross, Herts, for use either with the open arc process using continuous coated electrodes or with the submerged arc process using powder flux. The welding head of this equipment can be supplied either as a separate unit or it can be mounted on a self-propelled carriage. This carriage operates at speeds which are infinitely variable between 8in and 80in per minute and it has provision for free steering or running on tracks.

The equipment is suitable for use with either a.c. or d.c. welding power supplies and for welding currents of up to 1200A. The operator's controls, conveniently grouped in a small cabinet close to the welding head, include a multi-purpose instrument for checking the arc volts and welding current and facilities for remote control. A main control box houses the necessary relays, contactors and timing devices, &c. This "Muramatic" equipment can also be supplied with a separate power pack, consisting essentially of a transformer for a.c. welding or a "Dynex" generator for d.c. welding. The current is infinitely adjustable within the range of the equipment in all cases.

Typical of the power packs for use with the automatic sets is the 1200A a.c. pack, which comprises an 86/108kVA single-phase transformer with a primary suitable for connection to two phases of a 380V, 400V, 420V or 440V, three-phase, 50 c/s supply. This transformer is housed in a tank, together with a motorised moving core regulator, with a current range of 300/1200A, and complete with a push-button control panel and current indicating gear to give means of remote adjustment from the welding point. The complimentary 1200A d.c. pack has a welding generator, mounted on the same shaft in the same frame as a squirrel-cage motor. Output of the generator is infinitely variable from 350A to 1200A at 40 arc volts, and the open circuit voltage is 75. The current control is motorised to permit remote adjustment from welding operators' panel on a deck welding or similar equipment. The squirrel-cage motor is designed for connection to 400/440V, three-phase, 50 c/s supply, and the unit is complete with the necessary rectifier for supplying the generator field and a hand-operated, totally enclosed, oil-immersed star-delta starter with no-volt and over-load releases.

A new range of multi-operator welding transformers has been introduced for supplying three, six, nine, twelve and fifteen operators at 250A each; for three, six, nine, twelve and fifteen operators at 350A each; for three, six, nine and twelve operators at 450A each, and for three and six operators at 600A each. The primary windings are suitable for connection to 380/440V, three-phase, 50 c/s supplies, and all the transformers comply with B.S. 638 : 1954, Part 4. Also to be seen upon the stand is a model of a new regulator, which is rated at 35–350A for continuous hand welding, and is tapped, giving forty-nine current adjustments. It is calibrated for use with long leads and is housed in a round tank for ease of movement. Similar regulators for 250A, 450A and 600A are also available.

A display of some seventy kinds of welding electrodes includes the "Fastex 100," which has been developed for the rapid welding of pipe joints *in situ*, using the "stovepipe" or vertical downwards technique, as well as for general-purpose welding. The "Fortrex 35A" electrode shown has been specially designed for welding the extra thick plates being increasingly used for nuclear energy vessels. Its weld metal is stated to provide very high impact properties throughout the whole section of the welded joint at sub-zero temperatures.

Vokes, Ltd.

A new product of Vokes, Ltd., Henley Park, near Guildford, Surrey, is a large capacity automatic screen air filter in which a roll fibrous filtering medium is mounted between two spools, the upper spool containing the clean medium and the lower spool the soiled medium. The air flow aperture is arranged between the upper and lower spools, and passage of the filter medium across this aperture on to the lower spool is effected automatically by a geared motor drive which operates intermittently on a time cycle or by the operation of a pressure differential switch. The new equipment is known under the trade name "Autoroll" and a typical filter arrangement can be seen in Fig. 53.

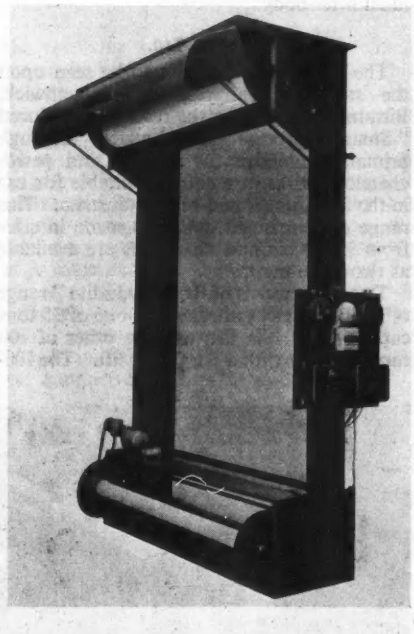


Fig. 53—Large capacity air filtering equipment with automatic intermittent feed of new filtering medium from clean roll on top spool across air flow aperture to bottom spool—Vokes

These equipments are intended for large air-conditioning, filtering or ventilation systems, and are made in standard widths of 3ft, 4ft and 5ft and any required height from 6ft to 15ft in 4in increments. The fabricated steel frame incorporates spool housings at the top and bottom and the clean spool at the top is located by spring-loaded side plates which apply a slight frictional braking force against rotation. The lower

take-up spool is driven by a geared motor through a chain and sprockets, the spool sprocket incorporating a free-wheel mechanism. Side sealing recesses in the frame minimise risk of the filter medium pulling out and causing leakage, and guide rollers are fitted at the top and bottom of the frame adjacent to the spools.

Actuation of the geared motor take-up drive of the lower spool is effected by a time switch, or by a pressure differential switch which operates as and when required according to the condition of the filtering medium. This drive inches new medium downwards from the top spool into the air stream. When the supply of clean medium is exhausted a strip of heavy Kraft paper fixed to the end of the roll is drawn down to blank off the upper part of the air aperture. A vane switch set near the top of the assembly then operates an audible or visual signal to indicate that servicing is necessary. At the same time, the motor drive is switched off to prevent further take-up on the bottom spool.

The filtering medium supplied for this equipment is in the form of a fibrous mat of even density and of ample strength to take the load imposed by the take-up drive. To reduce the risk of breakage or local tearing in service the filter is backed by a strong muslin on the clean air side. Some 225ft of standard medium can be accommodated on a 12in diameter spool. An equipment of somewhat similar construction and operation has been developed for use with a wire mesh panel filtering medium and incorporating an oil bath.

A number of this firm's large capacity lubricating filters of improved design include a new " top-servicing " marine equipment in which the filter element can be withdrawn from the top without disturbing the pipework or main filter body.

Tangyes, Ltd.

The pumping equipment to be seen upon the stand of Tangyes, Ltd., Smethwick, Birmingham, includes the recently introduced " Smart " process pump, which, although primarily intended for refining and petrochemical works, are equally suitable for use in the food, paper and other industries. This range of centrifugal pumps is made in sizes from ¾in to 6in and most sizes are available as two-stage pumps.

Two new models of the " Hydralite " range of hydraulic jacks are shown—one of 35 tons capacity and 18in lift, and the other of 100 tons capacity with a 6in power lift. The 100-ton jack is fitted with a new design of two-speed hand pump and either of the two speeds, giving low pressure or high pressure, is selected by a push button on the side of the pump. When this button is in its outer position, as shown in Fig. 56, the pump is

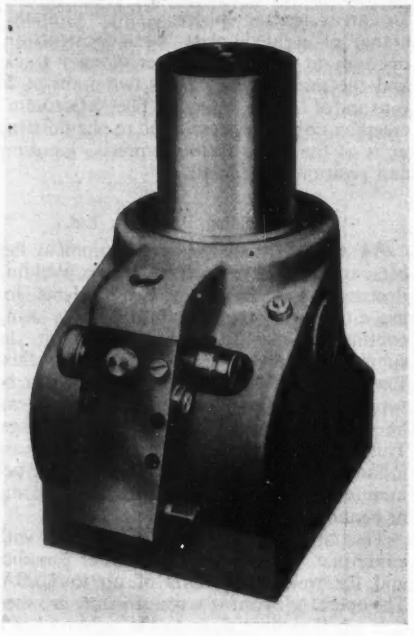


Fig. 56—100-ton, two-speed, hydraulic jack with a maximum power lift of 6in—Tangyes

on low-pressure operation, and the ram can be pumped out rapidly until it contacts the load. At this setting the pump reaches a pressure to lift 10 tons on the jack ; if the selection button is then pushed in, the jack is converted to high-pressure operation to raise loads up to 100 tons. A handwheel-operated needle valve is used to release the pressure in the pump and control the speed of ram descent under load. An automatic trip device comes into effect to prevent over-running of the ram on extension.

The " Hydrapak " pump fitted on the jack can be supplied as a basic unit for other applications, and some of its major components can be seen in Fig. 54. It has a simple rectangular body, which can readily be fitted on any flat surface. The high-pressure plunger is arranged to reciprocate inside the low-pressure plunger and the complete plunger assembly can be removed as a unit. When it is desired to change the high-pressure capacity of the pump, the plunger assembly is replaced by one having a high-pressure plunger of the required size, and high-pressure plungers are available to cover a pressure range from 1600 lb to 10,000 lb per square inch. The outside diameter of the low-pressure plunger is a common size and it operates at a maximum pressure of 750 lb per square inch. This low-pressure plunger is designed to deliver 3·1 cubic inches of liquid per stroke, or the equivalent of 1 pint in eleven full strokes.

In our issue of January 27, 1956, we described an interesting design of climbing jack developed by Tangyes for raising the sliding shuttering in the construction of large concrete sugar silos. Examples of these jacks shown on the stand are designed to climb a 1in steel bar while attached to a weight of 3 tons. Forty or fifty of these jacks can be operated simultaneously from one pressure pump and a model of a silo on the stand shows their application.

In addition to other forms of the firm's hydraulic and pumping equipment, a model of one of its hydraulic presses is exhibited as well as two horizontal slow-speed diesel engines—one of 12 b.h.p. at 900 r.p.m. and one of 36 b.h.p.

Hilmor, Ltd.

Hand-operated and mechanised tube benders of many sizes and types are to be seen on the stand of Hilmor, Ltd., Caxton Way, Stevenage, Herts. One of the machines shown in operation is the firm's " H.M.4.B." heavy-duty, general-purpose, non-mandrel bender illustrated in Fig. 55. It is designed to bend tubes cold up to 180 deg., and has a maximum capacity of 5in with non-ferrous and 4½in diameter with ferrous tubes. It will produce sets, double-sets, simple and compound bends in similar and different planes to predetermined measurements.

The fabricated steel base of the machine carries a high grade cast iron table and houses the 5 h.p. driving motor at the rear. Drive is transmitted through a servo clutch and chains to a worm reduction gearbox, and final drive to the bending arm is through a toothed dog engaging with a large gear ring on the periphery of the table. The bending arm is carried on a large phosphor bronze bearing and rotates about the centre of the table. It carries a hardened and ground steel roller in a cast housing, which is adjust-

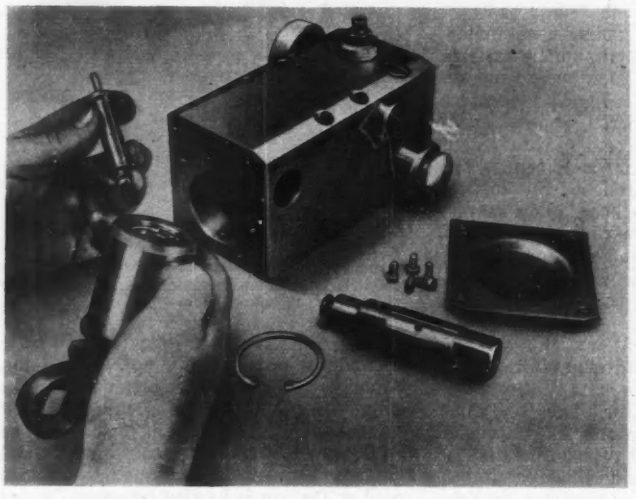


Fig. 54—Two-speed, hand-operated " Hydrapak " hydraulic pump with plunger assembly removed—Tangyes

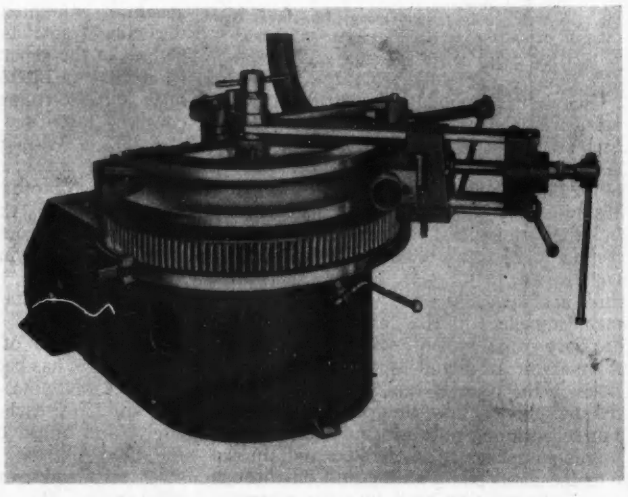


Fig. 55—General-purpose, heavy-duty, cold-bending machine for non-ferrous tubes up to 5in diameter and ferrous tubes up to 4½in diameter—Hilmor

able over the length of the arm by means of a screw.

A heavy bracket bolted and dowelled to the table locates the former and provides the anchorage for the tube stop. This tube stop can be adjusted over the whole range of the machine and it swivels to conform with the angle of the tube.

Two loose aluminium inserts can be fitted to the stop to prevent marking of tubes. A hardened and ground centre pin is used to locate and secure formers and a former stop can be used to give extra support when required. The degree of bend is determined by the automatic disengagement of the clutch by contact of the bending arm with a stop on a graduated quadrant.

Lincoln Electric Company, Ltd.

The welding equipment demonstrated by the Lincoln Electric Company, Ltd., Welwyn Garden City, Herts, includes one of the firm's SA150 motor generator sets arranged for tacking and hard welding. This particular unit is intended for use by firms wishing to build their own mobile welding sets. Two SAE600 motor generator sets are shown, one in use with a " Lincolnweld " tractor unit and the other with an ML2 manually operated semi-automatic submerged arc set with remote control.

The new B.10 automatic welding head illustrated in Fig. 57, is a redesigned and improved version of the earlier LAF-2 submerged arc welding head. This head incorporates an improved flux valve which can be adapted for automatic control.

A redesigned nozzle assembly makes positioning accurate and easy, and incorporates a flux shroud which gives good flux coverage. Spring-loaded jaws can be fitted, for use when high welding currents are employed.

An important improvement is the provision of a compound slide mounting, giving up to 6in vertical adjustment, 4in horizontal movement and angular setting of the head up to 40 deg. from the vertical position. This mounting enables the welding head to be attached to any beam, carriage or static point. The plain front of the carriage permits slide units of any size to be fitted, so that a very wide range of work sizes can be handled with the head mounted on a static beam.

The wire reel assembly mounted at the back of the carriage acts as a counterbalance, and the angle and height of the wire feed reel can be adjusted to suit the position of the head, to give smooth feed of the wire. The wire drive rolls will handle electrodes of all sizes without necessity for changing and the hopper and control station are now hinged to the wire feed box to give easy access to the drive roll assembly.

A guide light which replaces the pointer provided on the LAF-2 head throws a clearly visible cross, which can be seen from any angle or position and which enables the operator to check with ease and accuracy the alignment of the arc with the joint.

The use of Ward-Leonard control on the head gives infinitely variable welding speeds between 4in and 80in per minute. Two speed ranges are provided, one of 4in to 40in per minute and the other up to 80in per minute ; change is made from one speed range to the other by a rotary switch. An important point in the construction of this new head is that it can be " broken down " and the units rearranged to suit the particular requirements of the user.

The " Remotrol " remote control for hand welding applications can be fitted to enable an operator to vary from a remote position the current control reactor on " Lincoln " arc welding generators. It consists of an electric motor driving the reactor through reduction gearing, and can operate in either direction according to the position of the control switch. To prevent stalling of the motor at each end of the reactor, and to facilitate hand adjustment, the drive includes a friction clutch. The unit may be connected to either the welder output or the exciter output of the generator, and is controlled by a three-position switch.

Smiths Industrial Instruments, Ltd.

An interesting range of tachometers, counters, indicators and gauges has been arranged by Smiths Industrial Instruments, Ltd., of North Circular Road, London, N.W.2. A new instrument to be seen on this stand is a speed sensitive switch designed for over-speed protection, under-speed protection and starter circuit control. Within this switch assembly an input spindle drives a squirrel cage in which there are inserted a series of copper bars. Enclosed in the cage is a cylindrical magnet, and this is attached to a secondary spindle which, in turn, is affixed to a cam regulated by a helical spring. The tension of the spring is adjustable and operates in accordance with the predetermined revolution speed.

As the magnet is magnetised across its diameter, a current is induced in the bars of the revolving squirrel cage, and sets up a magnetic field. The reaction between this field and the field of the magnet will be a force; the intensity of which depends upon the input speed. This relative force tends to rotate the magnet in the same direction as the input spindle and cage ; and, consequently, it moves until the torque is neutralised by that of the spring. The cam, fitted to the secondary spindle, operates a micro switch at a value determined by the tension of the spring. Temperature compensation is achieved by a thermo-magnetic shunt. The entire mechanism is installed in a body of robust construction, and its few moving parts are conducive to long life and reliability.

A new calibrated relay, illustrated in Fig. 58, fitted with a transparent cover, is suitable for use on internal combustion engines where starter overload and overspeed protection is required. It is designed to maintain and control voltage, current and speed as applied to starter and overspeed protection. It is stated to be a new approach to the problem of closing a pair of contacts at a given electrical input.

Basically the relay consists of a permanent magnet and moving coil system, which gives a very effective electro-mechanical conversion. Precision is achieved by a magnetic lock which is adjusted to a predetermined value.

The outstanding characteristics of this calibrated relay are claimed to be the high accuracy of ± 1 per cent under static condition, and the very low power input, which is approximately 30mW. The $\frac{1}{4}$in clearance between contacts, except at closure, eliminates the possibility of maloperation due to vibration, and the sealed contact compartment with its transparent cover is designed to ensure reliable performance under extreme

Fig. 58—Calibrated relay for use on engines where starter overload and overspeed protection is required —Smiths

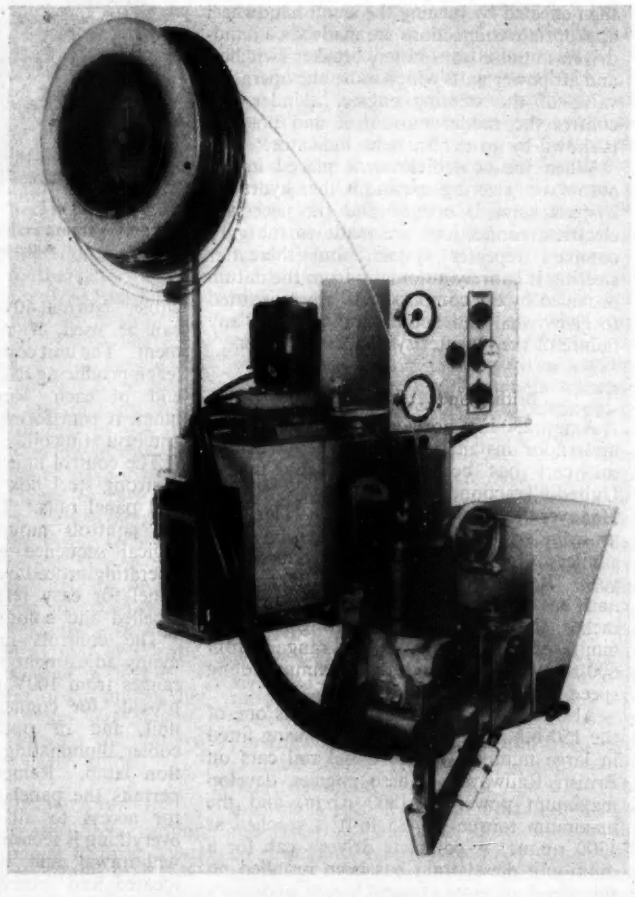


Fig. 57—Automatic welding head which can be broken down for reassembly to suit individual requirements—Lincoln

temperature conditions. Contact pressure is between 15 grammes and 60 grammes and the accuracy of setting is not adversely influenced by contact wear. At approximately 50 per cent of the setting current, automatic reset is effected.

S. G. Brown, Ltd.

An equipment of particular interest on the stand of S. G. Brown, Ltd., Shakespeare Street, Watford, Herts, is the combined steering console we illustrate in Fig. 59. In this single bridge-mounting console there are combined a hydraulic telemotor-transmitted bridge control and equipment for automatic steering from a datum provided by a gyroscopic compass. The automatic steering system can also be operated by a small handwheel independently of the gyro compass to provide a third alternative in the form of manually operated electric steering.

The interior of the console can be seen in our second illustration (Fig. 60). A vertical partition divides the console interior into two parts. The section forward of the operating position houses the bridge telemotor pump unit, and that nearest the large and small handwheels houses the apparatus associated with the Brown automatic and hand electric steering systems, cable connections, &c. Surmounting the unit is the Brown multiple steering repeater with an expanded scale giving degree readings a quarter of an inch wide.

On the port side of the console a lever having three definite locating positions provides for hydraulic, hand-electric and automatic steering. With this lever set in the hydraulic position steering is effected by appropriate movement of the large handwheel to port or starboard, when the rudder position obtained is indicated by the large mechanically operated pointer as normally supplied with telemotor equipment. There is no connection electrically or mechanically with the gyro compass, but the ship's head may be read from the indication of the steering repeater when the compass is running. Dials on the console show the operating pressure in each hydraulic pipeline ; suitable bleed valves are incorporated, two above the the handwheel, and one near the top on the

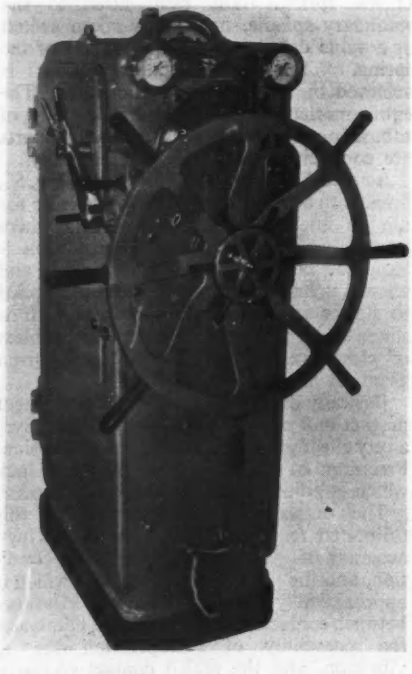


Fig. 59—Steering console combining a hydraulic telemeter transmitted bridge control, automatic steering and hand-electric steering—Brown

Fig. 60—Interior of steering console with telemeter pump unit in right-hand compartment and the automatic and hand-electric steering equipment in the left-hand compartment—Brown

port and starboard side. In this position of the main control lever the by-pass valve of the hydraulic system is fully closed.

When the control lever is set in the hand-electric position the by-pass valve mentioned above is opened and at the same time electrical connection made to the appropriate units in the Brown steering system. When steering is then effected by turning the small handwheel appropriate connections are made via a hand-driven impulse transmitter, breaker switches, and aft power units which move the operating valve of the steering engine. Under this control the rudder movement and position is shown by an electric helm indicator.

When the control lever is placed in the automatic steering position the hydraulic by-pass valve is opened and the necessary electrical connections are made to the gyro compass repeater system, and thereafter steering is entirely automatic from the datum provided by the compass. An alarm is fitted to give visual and audible indication of any failure of the repeater system.

British United Traction, Ltd.

A new 230 h.p. horizontal diesel engine for underfloor installation in lightweight diesel rail cars has been developed by British United Traction, Ltd., Hanover House, Hanover Square, London, W.1. This new six-cylinder, direct injection engine is basically similar to the 200 h.p. engine introduced last year. It develops 230 b.h.p. at 1900 r.p.m. and has a cubic capacity of 926·6 cubic inches, the bore and stroke being 5½in and 6in, respectively. The full-load range is from 600 to 1900 r.p.m. and the maximum idling speed is 400 r.p.m.

Also shown on this firm's stand is one of the 150 b.h.p. engines which are being fitted in large numbers to the diesel rail cars on British Railways. These engines develop maximum power at 1800 r.p.m. and the maximum torque of 485 lb-ft is reached at 1300 r.p.m. A complete driver's cab for a multi-unit diesel train has been installed on this stand, to show a typical layout of driver's controls and electro-pneumatic controls for the power and transmission units.

Marconi Instruments, Ltd.

A new transportable industrial X-ray apparatus type "TF 1593" made by Marconi Instruments, Ltd., St. Albans, is shown on the stand of the English Electric Company, Ltd. This equipment (Fig. 61) is of robust construction, being dust-proofed and spray-proofed to make it suitable for field, workshop or laboratory installations, and under most conditions it can be set up ready for use within ten minutes of arrival on site. It comprises two transportable units, connected during operation by a low-tension cable, and a number of accessories which are contained in a metal case are available optionally. The rating of the basic equipment is 5mA at 175kVp (continuous) or up to 8mA for fifteen minutes alternating with fifteen-minute cooling intervals. Use of an optional cooling fan permits somewhat higher ratings.

The h.t. transformer tube unit is basically designed for the 360 deg. circumferential technique and comprises a cylindrical unit which can be placed inside vessels or pipes, to provide a single radiograph of an entire circumferential weld. Alternatively, the unit can be used to radiograph, in a single exposure, a number of objects arranged in a

Fig. 61—Transportable 175kVp industrial X-ray equipment—Marconi

circle. Normal 40 deg. cone beam techniques can be used, if required, with the equipment. The unit contains two h.t. transformers (each producing half the kilovoltage with one end of each winding earthed), a tube filament transformer, an X-ray insert tube, and insulating oil.

The control unit is a compact assembly in a strong steel box having a detachable lid and panel rails. The control panel has all the controls mounted and grouped in a logical sequence and a summary of the operating procedure is engraved on the front panel for easy reference. Each control is labelled and colour coded.

The controls include coarse and fine mains adjustment tap switches which cover ranges from 100V to 450V. Keyed sockets provide for connection of mains and h.t. unit, and of optional items such as a cooler, illuminating beam director and inspection lamp. Removal of four fixing bolts permits the panel to be lifted by the rails for access to all components below, and everything is secured to the panel to facilitate withdrawal and inspection. The unit is located and secured internally on resilient anti-shock mountings.

(*To be continued*)

Technology and World Advancement

By PROFESSOR P. M. S. BLACKETT, F.R.S.

In his Presidential Address to the British Association, delivered last Wednesday, September 4, Professor Blackett discussed the very uneven distribution of material wealth in the world to-day. The peoples of the highly industrialised countries have an average income per head of £300 at 1949 prices, whereas those of "pre-industrial" countries have only £20. The Western world is saving and investing productively some £30 a head per year, 50 per cent more than an average Asiatic in a pre-industrial country has, to cover both consumption and production. He points out that the disparity of wealth is likely to become more marked. After discussing the conditions which encourage a pre-industrial country to "take off into sustained growth," he pleads for really substantial financial assistance at a rate of some £1000 million per year from the West to help undeveloped countries, to give them, in fact, an "assisted take-off." Long excerpts from the Address are printed here.

THOUGH few to-day in the rich Western world are naïve enough to think that an increase of material wealth necessarily results in a corresponding increase of human happiness and personal fulfilment, yet few would deny the validity of using a nation's material wealth as a measure of its potential welfare.

Uneven Distribution of Wealth

One of the most striking features of our contemporary world is the very uneven distribution of material wealth. Leaving aside the countries in the Soviet orbit, as needing separate discussion which will not be attempted, we have at the one extreme the highly industrialised countries of Europe and of North America and Australasia, with, in round figures, a population of 400 million, and an average income a head of £300 a year (at 1949 prices). For Europe alone the average is £200 a year. Within this group of relatively rich Western countries there is, of course, a wide range of average income, from one-third to more than double the average. Three hundred years ago, the pre-industrial countries of Europe had a real income a head of not much more than one-tenth of what it is to-day. In the last half-century their wealth has been increasing at a rough average of nearly 2 per cent a head every year, thus doubling in rather less than forty years. This huge and historically rapid rise in individual wealth was accompanied by a very large rise in population.

In marked contrast to the rich West are the still pre-industrial countries, particularly those of Asia, Africa and South America. These—excluding Soviet China—have a population of some 1000 million people and an average income of about £20 a year a head—that is, one-tenth that of Europe and a still smaller fraction of that of the West as a whole. Moreover, this low income does not, on the average, seem to have increased much during the last three centuries and may at times have fallen, despite the revolutionary improvements in world technology as a whole during this period. It seems from such figures that 300 years ago the standard of life in at least the more advanced nations of the East, such as China, India or Persia, must have been as high as that of Europe. The gap now of ten to one in favour of Europe is of quite recent origin and is due to the sudden advance of the West, mainly in the last 200 years, whereas the Eastern countries have remained nearly static.

Take-off into Sustained Growth

Economists have recently been turning their attention to the complex historic causes which lead a country to transform itself from a static pre-industrial state to a growing industrial one. Making apt use of an aeronautical metaphor, the American economist Rostow has named this vital period of transition "the take-off into sustained growth." In Britain, the first country to become fully industrialised, this critical period seems to have been the last twenty years of the eighteenth century.

In a typical pre-industrial country, three-quarters or more of the population may be engaged in agriculture, and wealth tends to remain constant or rises but slowly. Savings and gross investment are low, some 5 per cent or less of the national income—that is, only about enough to maintain a static economy by paying for the depreciation of existing wealth. After take-off, savings and gross investment rise till some 15 per cent of the national income is available for gross investment, leaving around 10 per cent for net new productive investment. On the average in the West to-day such new investment results in a rise of gross income of about 3 per cent a year. Allowing for the population rise of some 1 per cent, this gives an increase of wealth a head around 2 per cent a year. The fraction of the population engaged in agriculture steadily falls as social development and industrialisation proceed, and agriculture itself becomes partly industrialised and so much more efficient. In Britain, the savings and investment required for take-off were essentially provided by the prosperous classes who did not spend their surplus wealth on ostentatious living, but invested it in productive industry.

Everyone recognises that most scientific and technological innovations can lead to continually increasing wealth only when they become embodied in material things, particularly production goods, such as machine tools, chemical and fertiliser plants, transport and communication systems. Nuclear power, the outstanding technical development of this decade, adds to wealth only when nuclear power stations have been built. However, the large amount of capital required is not always appreciated, especially by scientists and inventors, who naturally wish to see their discoveries and inventions used. For heavy basic industries, such as steel, oil refining or heavy chemicals, a capital of £5000 to £10,000 a man employed is required; for medium and light manufacturing industries perhaps from £1000 to £3000. Such sums must come from governmental, corporate or personal savings—that is, at the expense of present consumption; or, alternatively, from external loans. The high capital cost of industrialisation is the main reason why the take-off is such a difficult operation for the pre-industrial countries. This is especially so at present because most production goods must be imported, thus making heavy demands on foreign exchange, which, except in a few oil and mineral-producing countries, is chronically short.

Saving and Spending

In addition to maintaining its existing wealth, the Western world is saving and investing productively some 10 per cent of its income of £300 a year a head—that is, some £30 a year a head is being invested in additional plant and machinery to create more wealth. The pre-industrial countries of Asia only have about £20 a head to live on—that is, for both consumption and production goods. The West is thus saving more than the East is spending on everything. No wonder that the gap in wealth between the West and Asia is steadily widening. Moreover, most new scientific and technical discoveries or developments tend to widen the gap still more just because the already rich countries have the capital to make full use of them, but the poor countries have not. For instance, under present conditions, the advent of nuclear power must tend to widen the absolute gap still further, because of the high capital expense of nuclear power stations. Decidedly, scientific and technical invention is no fairy wand to wave over a poor country to transform it into a rich one.

The Needs of Underdeveloped Countries

Anyone who wishes to make himself familiar in detail with the degree of poverty of the underdeveloped countries of the world, particularly those of South-East Asia, India, Pakistan, Ceylon, Burma, Indo-China and Indonesia, will find abundant material at his disposal. In recent years there has been a spate of blue books, white papers, newspaper leaders, speeches, tracts and academic treatises, in which can be found statistics, eloquent writing, moral and political fervour. Of special importance were President Truman's "Point Four" in his inaugural speech in 1949, and the Colombo Plan in 1950.

When, after the second world war, these countries threw off alien rule, the ills of South-East Asia—poverty, underfeeding, disease and illiteracy—became important factors in international relations. These new independent countries became free to make their own external and foreign policy, based on their own views of their own interests. They can now choose for themselves with which countries they will trade or with which they will have close diplomatic or military relations. Moreover, no political party in these new Asian countries can hope to maintain itself long in power if it does not succeed in improving the lot of its people. The pre-industrial countries of the East can only become less poor by saving and investing money in better education, agriculture, social services and industrialisation. If they are to do this out of their own resources alone, they must inevitably increase their poverty temporarily.

Several careful investigations have been made of the needs for external financial aid in the form of long-term loans and gifts to enable all these have-not countries to make a good start on the road to prosperity. It seems that the immediate need is not far from the round figure of £1000 million a year—that is, £1 a year for each of the 1000 million inhabitants of these countries. It is difficult to ascertain the amount actually made available for other than defence purposes from the Western nations under the various aid schemes, such as the Colombo Plan, the Colonial Development projects, technical aid through the United Nations, and through various bilateral agreements. Though quite considerable, the amount is almost certainly only a fraction of the above requirement.

The Situation in India

Since, of all the former dependent countries, India has the best-worked-out plan of social advance and, moreover, is much the largest, it will be convenient to discuss her situation in some detail. Many of the problems facing India are common to other underdeveloped countries, whether in South-East Asia, Africa or South America. The Planning Commission in New Delhi is aided by a powerful statistical and economic group in Calcutta, presided over by a mathematical statistician, Professor Mahalanobis, Fellow of the Royal Society of London. This research group has been assisted by economists from both Western and Soviet countries in the study of the problem of how India can most easily, quickly and painlessly emerge from the nearly static and essentially pre-industrial state in which she found herself on attaining independence in 1947.

During the period of the first Indian five-year plan ending in 1956, the national income rose by 18 per cent. This is an important, even if precarious, achievement, in marked contrast to the stagnation of the previous decades. In the second five-year period, 1956–61, a rise of national income of 25 per cent is planned—that is, 5 per cent a year. Whether India can achieve this without additional external financial aid is now doubtful, especially in view of her present large deficiency in her balance of payments. The plan involves not only attaining the high rate of new productive investment of at least 10 per cent of the national income, but also an annual return of 50 per cent in terms of additional output on the capital invested. Such a high net marginal return on capital can only result from very wise planning and efficient execution of the overall pattern of development. Allowing for the population rise of 1·3 per cent a year, the planned rise of income a head is 5 per cent minus 1·3 per cent, or 3·7 per cent a year.

Such a rate of rise, if achieved, would be nearly twice the average of Western Europe at the present time. So the relative gap—that is, the ratio between the living standards of India and Europe—would slowly begin to close. But how slowly! If these rates continued, nearly half a century would elapse before the living standard of India would climb from one-tenth to one-fifth of that of Europe. Moreover, the actual difference between the living standards—that is, the absolute gap—would still widen; for instance, if the assumed rates of advance are maintained for the next ten years, the rise of annual income of a European will be much more than the final income of an Indian.

The limit of India's possible rate of advance is set mainly by the available capital for productive investment, and particularly of foreign exchange to buy production goods from other countries. Failing massive external aid, the advance is limited to what a democratic parliamentary government of a very poor country can raise internally by taxation and loans.

Science and Industrial Arts

What is the historical origin of the astonishing differences to-day between the economic and social conditions of the West and the East? A whole host of hypothetical causes have been advanced: differences in natural ability, climate, health, food, natural resources, religions, social systems or methods of government. To attempt an answer to this problem, it is necessary to look deeply into history.

Abundant evidence proves the high level of technological achievement at a very early date. The astonishing building feats of the Egyptians and Mesopotamians are world-famous. Less widely known are the gigantic town-planned cities of Northern India, such as Mohenjo Daro, which flourished over 4000 years ago, with their main drainage systems, vast granaries, and citizens' houses far better than those lived in by most Indians to-day. Innumerable examples abound in our museums or are illustrated in our histories, demonstrating the astonishing technical triumphs of antiquity. The stern beauty of the 4000-year-old bronze head of Sargon the Great, or the overpowering grandeur of the 3000-year-old inner coffin of Tutankhamen, alone suffice to prove that the highest artistry was allied to superb technical skill. The modernity in design of many articles of domestic use in ancient times is most striking. A wooden chair or a manicure set from the Egyptian New Empire of 1000 B.C. would not look out of place in the most up-to-date shop window to-day, and might well be better made. A high level of domestic culture was by no means restricted to a few monarchs and officials. The cities of Crete, Babylonia and Egypt around 2000 B.C. must have abounded in comfortable and cultivated people who led very pleasant lives, almost as refined and luxurious as prosperous people enjoy to-day. In the material arts of life one is constantly impressed by the absence of many major improvements between the height of the great Middle and Far Eastern Empires and the rise of modern technology in Europe about the eighteenth century A.D. Except for the last 200 years, Rudyard Kipling was not far wrong when he wrote:

> We tell these tales, which are strictly true,
> Just by way of convincing you
> How very little, since things was made,
> Anything alters in any one's trade.

During the first 200 years of modern science, from 1600 to 1800, science learnt much from technology, but taught it relatively little. The empirical industrial arts were already so highly developed, and indeed had been so for thousands of years, that systematic science had to develop far before it could improve decisively on pre-scientific technology. Even to-day, the biochemist cannot teach a chef how to cook a better omelette. Despite the interest of the Royal Society in the "useful arts," it was not until the last quarter of the eighteenth century that the impact of science on technology began to be decisively important.

Why it Happened

The vast developments from the seventeenth century to the present day have been almost exclusively a Western achievement. Though the technological foundations on which Europe built arose mainly in the countries of the Near and Far East, these have hardly as yet shared in the later scientific and industrial revolution. To the question why what happened did happen, I do not think there is an agreed answer. Certainly it had nothing to do with any inherent European superiority—indeed, the history of the previous millennia might well have suggested the opposite. Most probably it was differences in social and economic organisation which were the decisive factors. Amongst the positive factors was certainly the growth after the eleventh century of the city states of Italy, followed by the free cities of Northern Europe, where merchant entrepreneurs were free from many of the restrictions of feudal society. Not noble but not poor, these men, much like the Ionians of Thales' time 2000 years earlier, had a pecuniary interest in exploration and in technical innovation. This positive drive towards technological and social change in Europe might not have been sufficient to produce much more than a temporary spurt of pre-scientific technological advance had it not been for the scientific revolution which in the seventeenth and eighteenth centuries grew out of it.

After 2000 years of relative stagnation of world technology, Europeans staged a scientific, technological and industrial revolution, which has transformed within three centuries, and is still transforming, both the material way of life and the mental outlook of mankind. This astonishing achievement of the peoples of Europe must rank with the greatest events of world history. During the centuries when European scientists, technologists and craftsmen were conquering nature, European fighting men, missionaries, traders and administrators were conquering the world. By the close of the nineteenth century 100 million Europeans were ruling some 700 million people in Asia, Africa and America.

Innate Mental Differences

Understandably, this double and interrelated triumph of the West over both Nature and the world went to its head. By the last half of the nineteenth century the doctrine of the innate superiority of the white peoples, with its corollary of the inferiority and incapability of coloured people, had become widely accepted in the West. To a great extent, white racialism is economic and administrative in origin. Men tend to feel superior to those whom they rule and to despise those whom they exploit.

What has science to say of the innate mental differences between the different races of mankind? Rather little, it seems—at any rate—so far. The physical differences of colour, features and stature are obvious without the aid of scientific study. It may well be that innate differences of mental make-up do exist: but scientific study has failed as yet to establish their existence or nature. Moreover, even if mental and temperamental differences could be demonstrated as innate in such qualities as courage and determination of purpose, physical strength and skill, or in musical, literary, artistic, mathematical and analytical power, between the individuals of different races, the attempt to rate different races in an acceptable general order of merit is foredoomed to failure. For no agreement would be obtainable on the relative weight to be attached to the various abilities: indeed, the various human qualities have different values in different environments.

Even if further studies should show marked differences now between different races, it would be as dangerous to extrapolate too far forward into the future just as the history of technology has shown it to be dangerous to extrapolate back into even the relatively recent past. The artistic and technical triumphs during the Middle Ages of Peru, Mexico, India, Indo-China and China are a perpetual reminder that great creative ability and immense energy have appeared quite recently among many different peoples, with diverse social systems and religions, and vastly different climates. The grandeur of Cusco, Chichen-Itza, Fatehpur-sikri, Angkor Vat and the Forbidden City in Pekin are permanent memorials of not very distant achievements of the coloured peoples of the world.

Technical Advice

I am convinced that Western pessimism about the possibility of social advance by ex-colonial Asian countries is both unjustified in fact and a serious cause of practical error.

It has led the West to overestimate the need of the have-not-countries for technical advice from Western experts and to underestimate the need for simple financial help. Admirable as many of the schemes of technical aid have been, particularly those in education, medicine and agriculture, the sending of experts to poor countries without the capital to carry out their plans, could be as irritating as to send a trained cook to a family unable to pay the baker. In so far as expert aid by Western technical personnel is needed by an under-developed country, it is usually both more efficient and cheaper to provide money for the country itself to hire those whom it needs. Unless followed up by massive financial help, some of the West's present aid programme may yet merit the wartime wisecrack of "offering all aid short of help."

What would constitute real help ? The figures already given suggest that in addition to likely commercial and government short-term lending an additional £1000 million a year is needed as a free gift or as long-term loans from the 400 million rich Westerners to the 1000 million Asians, Africans and South Americans in the under-developed countries outside the Soviet orbit. To the Western donors, this would amount to a levy of less that 1 per cent of their income ; Britain would pay £150 million a year, and this would only postpone by less than a year the expected rise of 50 per cent in British living standards over the next quarter of a century. To the recipient country, it would mean £1 a year a head in foreign exchange, that is, a 5 per cent addition to their income of £20 a year. If wisely invested, this should allow the standard of life to rise at rather more than an extra 2 per cent a year. It would therefore make an appreciable contribution to the outstanding problem of the widening gap.

Such aid to a nation with a well-developed national plan would probably not be needed for more than a limited period, perhaps one or two decades. By then she should have achieved the take-off and be a in a state of sustained economic growth, able to dispense with outside aid. Extending the aeronautical metaphor, the suggested Western action would amount to using its great wealth and material power to give the have-not countries an assisted take-off. It must always be remembered that without a strong and intelligently directed internal drive for social betterment, no country can achieve much. Outside aid can only help fully those who are already prepared to help themselves to the limit of their capacity.

Operational Research: the Common Factor

By SIR CHARLES GOODEVE, F.R.S.

THIS week, from September 2 to 6, Oxford is housing the first international conference on operational research, sponsored by the three chief operational research societies in this country and the U.S.A., with the support of the corresponding societies in France and in other countries. On the first four days, 250 delegates from twenty-one countries are to discuss thirty-five papers on methods and applications of operational research (O.R.). On the fifth, groups of delegates with specialised interests will meet some of their British colleagues *in situ* to discuss common problems ; for example, those interested in processing industries will reassemble in Coventry, those in air transport at London Airport, those in agriculture, fuel and power, iron and steel production, computers, road transport, and small unit industries respectively at other appropriate locations.

Present State of Operational Research

Nearly twenty years have passed since the complicated military and logistic operations of World War II were first tackled by a kind of research to which they gave their name. The purpose of operational research, in the words of one of its pioneers, Sir Robert Watson-Watt, was to obtain the "maximum effect from available resources." This was to be achieved by subjecting operational problems facing decision makers to a systematic scientific analysis and to determine as accurately as possible the outcome of alternative courses of action. Executive decisions would thus be provided with a scientific foundation. Watson-Watt himself was chiefly concerned with the most effective use of radar. Others, recruited for operational research from many branches of science, attacked such varied problems as the optimal sizes of shipping convoys, the most efficacious deployment of anti-aircraft gunfire, the organisation of aircraft maintenance, and the development of strategies for finding and destroying enemy submarines. Though the problems were military, the teams organised to deal with them were largely composed of civilian scientists—both in the British and U.S. forces ; the extension of operational research methods into social and industrial fields after the war was thus a foregone conclusion.

What is the state of O.R. on the eve of this week's conference ? What is it that attracts to a common discussion room the oil man from Australia, the American aircraft constructor, the electrical industry man from Holland, and the scientific adviser to the Government of India ? The answer that can be ventured is this : Hitherto, operational research has been employed in many places to deal with isolated and limited problems. To do this methods specific to the problem have been devised. The stage has now arrived when many of the results of operational research can be generalised. After nearly twenty years of existence, most of it in peacetime, the moment has come when the practices and principles of O.R. can be profitably discussed as a body. The timing of the conference as well as the attraction it exerts not merely on research workers from Western Europe and North America, where it is well developed, but also from Turkey, Japan, Poland, South Africa and other countries, where it has been substantially but less widely practiced, testifies to the fact that O.R. has attained maturity ; henceforth, the dissemination of its approach and methods to other nations will be further facilitated.

The programme of the conference, at first sight, offers little clue of common ground amongst the practitioners of O.R. It is not easy to find the unifying thread linking such papers as, for example, one from Israel on the organisation of systems of machine repair, a British paper on the traffic capacity of main road roundabouts, and a paper from Holland on telephone operations. Yet, as Dr. Glen Camp,* of the U.S. has so succinctly stated, there is such a link ; operational research, he points out, is concerned with the structure of operations, where operations are defined as activities " in which a responsible authority utilises available human and material resources to accomplish a specified purpose, which latter may be hindered or aided by chance environmental factors." The key term of Dr. Camp's definition is structure. The introduction of this concept makes it possible to discern the essential similarity of such phenomena as the handling of calls by a telephone switchboard, of traffic at an intersection, of diners through a restaurant and of machines through a repair shop. All these operations have the same structural characteristic, which consists in the arrival of a series of unco-ordinated (unplanned) demands at a " service gate " of a given capacity ; there will be periods when the capacity of the gate is not utilised to the full and also periods of queue formation.

In another class of processes a single raw material can be used to form several end products. Milk is separated from cream or turned into butter or cheese. Timber will become planks, paper or vitrose. Crude oil is separated into a hundred products and by-products.

A third structure, the reverse of this, is the operation of assembly, found in all the manufacturing industries. Dr. Camp writes : " The practical significance of the existence of structure, and of the common occurrence of similarity of structure is this : first, because operations have a structure they obey orderly, quantitative laws which can be discovered by the same general methods as, for example, the physicist uses in studying atoms. Second, because of the frequent similarity of structure, knowledge gained from the study of one operation is often very useful in the study of others. Thus, with the aid of men of long experience in a particular field of operations, it is often possible for an O.R. team to obtain valuable results in a very short time in another field, even though the team have had no previous experience in this particular operational area."

A brief comment is called for by Dr. Camp's inclusion in his definition of operations of the clause " which (purpose) may be hindered or aided by chance environmental factors." Operational research workers do, in fact, almost always encounter situations in which there is an element of chance or randomness ; often this element takes the form of a process, where the recurrence of one event is conditional upon the occurrence of another. Consequently, statistical and mathematical techniques are indispensable tools of O.R.; they are, however, by no means the only set of tools of a scientific discipline which has many other means of analysing operations and their structures.

Like his colleagues in every other field of science, the operational research worker starts out by asking questions both of himself and of other people : " What exactly is happening ? Why does it happen in just that way ? " The factors which produce a certain effect are seldom immediately obvious and are often highly interrelated and complex. Not infrequently, persistent questioning reveals that the problem as initially stated cannot be answered and that it must first be restructured. Where it has been possible to isolate the factors involved, the O.R. worker can then attempt to determine how they act individually and in various combinations to produce the results observed. Almost invariably this requires the construction of a

* " Operations Research ; The Science of Strategies and Tactics." Glen D. Camp. *Textile Research Journal*, Vol. 25 No. 7—July, 1955, pages 629–634.

"model." The model simulates reality or certain aspects of reality and has the advantage that it is easily manageable and can be altered or scrapped and reconstructed easily and at relatively little expense. In some cases it may consist of nothing more than a set of mathematical expressions, in others it may be mechanical, electrical or electrochemical. Its essential feature is that it must have the same "structure" as the real situation, so that an examination of its workings can be extrapolated to the actual situation. The use of such structurally similar or "isomorphic" models is, of course, not exclusive to O.R. Some of the most notable advances in every field of science have been achieved by mathematical and mechanical formulations which simulate reality to a greater or lesser extent. But O.R. personnel is commonly forced to display special ingenuity in designing models from exceedingly scanty and scrappy data, not infrequently amassed by people unfamiliar with the requirements of O.R. Furthermore, since most operational research deals with events in "going concerns," the workers have had to develop skill in extracting data from continuous uninterrupted processes; this often calls for unconventional and novel methods of fieldwork.

Model Building

Perhaps the most difficult, because the most critical, aspect of "model building" is in the selection of factors for inclusion. Obviously it is never possible to include all factors. On the other hand, the need for selection amongst them affords an opportunity for classifying their relative importance and hence contributes to the formulation of the problem itself. Sometimes rather intangible factors are met with which, however, are of such importance that they cannot be ignored. In these cases quantification or "firming up" is done in terms of assumptions agreed upon by the O.R. worker and his customer, the decision-maker or executive. Where quantification is impossible, such factors may still have to be indicated or given weight in the solution which is, in the final resort, the recommendation made to the executive.

In effect, the O.R. worker reports as a scientist to the executive that his model, constructed in part on the basis of available data and in part on mutually agreed assumptions, behaves upon the introduction of such and such alterations and changes in such and such a way; and that much of the same behaviour is likely to result if the same is done to the real operation. With a specified range of assumptions a corresponding range of outcomes can be predicted.

A typical example of the manner in which O.R. tackles a problem and presents conclusions and recommendations is contained in a paper to be given to the conference on the distribution of the coal supplies by the Central Electricity Authority to its various generating stations. Forty million tons a year from 800 collieries are sent to 200 power stations by rail, sea, canal and road. Transport costs total some £30,000,000 and vary considerably with distance, method and quantity. One of the main constraints which had to be built into the model was that not every generating station can take coal from every colliery. The O.R. team found that colliery outputs were not predictable with precision, nor were variations in demand due to breakdowns or other reasons; altogether, a problem of formidable complexity. There were many restrictions to be satisfied by the final solution. Some power stations can only use certain kinds of coal; some low grades of coal are too corrosive for use without blending. By using the technique of linear programming the investigators were able to minimise the transport cost of allocating the supplies of coal from the several sources to the stations at which they were required. But that was not all. Since the supply or demand for coal at the pithead or power station can undergo sudden unforeseen changes it was necessary to find a way of revising the calculation at short notice to meet such emergencies. An approximate way of programming by hand has been found by the research workers who are now constructing a simple mechanical analogue machine which will perform the calculations very quickly.

Linear Programming

The method employed in solving this problem was "linear programming"—a method which has many applications and illustrates the trend towards generalisation in O.R. to which reference has been made previously. It can be defined as a technique for planning a complex of interdependent activities to operate in the most economical manner. In more concrete terms it is a technique for charting the cheapest path through a maze of which the alleys are different conditions. In view of what has been said, it is not surprising (although not therefore any less heartening) that linear programming figures in many other papers to be read at the conference: planning operations in a chemical company, investment in generating plants of various kinds (hydroelectric, steam, tidal and atomic) in France, allocating electronic equipment to naval craft, determining which of half a dozen plants should ship tomato ketchup to each of the seventy warehouses in all parts of the U.S.A., and so on.

Queueing Theory

Another technique which will frequently be mentioned at the conference goes under the name of queueing theory; it has relevance to problems connected with the handling of demands at a service gate which have been briefly touched upon. In addition to papers dealing with its application to the arrival of calls at a switchboard, of vehicles at a crossing, and of machines at a repair shop—all of which has been instanced as typical of a certain structural group—queueing theory will be discussed in the context of ore mining, railway marshalling yard routine, and a speed-up in quoting prices to customers for a particular kind of product.

Many other techniques for investigating operation of certain well-defined structural characteristics could be enumerated in addition to linear programming and to queueing theory. The diversity of fields in which they have actually been used or in which they have potential application justifies the claim of operational research to a mature status. When all is said and done, however, neither the proliferation and elaboration of techniques and methods, nor the attainment of maturity can be regarded as yardsticks of the viability of Operational Research. Its progress and standing in the community of scientific disciplines will always ultimately depend on the capacity of O.R. workers to gain clear and penetrating insights into problems. Its survival in practice, similarly, will depend on the degree to which the executive will be prepared to regard the evidence presented to him as a reliable basis for taking decisions. Above all, O.R. must not allow itself to be sidetracked from its early description of "quantified common sense."

Cornish Engines Preservation Society

The 1957 annual general meeting of the Cornish Engines Preservation Society was held on Saturday, August 17, at Camborne. It was preceded on Friday, August 16, by a motor coach excursion to places in West Cornwall of interest to engineers.

The first of these excursions included stops at Trevithick Cottage, Penponds, Roseworthy Hammer Mill, Copperhouse Foundry and Harvey's Foundry, Hayle. At each stop brief accounts of the undertakings were given by Mr. T. R. Harris, and other members provided running commentaries on historical details with which they were familiar. A journey around the south and west flanks of Trencrom Hill led eventually to Zennor, where members inspected with great interest the display at the "Wayside Museum" under the guidance of the honorary curators, Mr. and Mrs. Quigley. The next stop was a Botallack—one of the most romantically situated of Cornish mines. Mr. W. T. Hooper outlined its history and members explored the ruins of engine-houses, many of which seem precariously perched part way down the cliff sides.

Following lunch, a similar site was visited—Levant. Mr. Hooper again read notes on this once-famous property. Of special interest to the party was the Beam Whim, as this was the Society's first acquisition. The route then lay across country to the other coast—to Trewavas Head, about 2 miles west of Porthleven. The engine-houses of the copper mine operating there in the first part of the eighteenth century are truly remarkable. All were impressed by the skill and daring of the Cornish engineers and miners responsible for getting the great Cornish engines down to, and erecting them on, narrow shelves between the top of the cliffs and the sea, under which the workings extended. It was explained that the shafts were sunk in such seemingly extraordinary places instead of on the level cliff top to save the driving of cross cuts to the lodes—an expensive proceeding in those days. Tea at Porthleven and the return to Camborne brought a very enjoyable day to a close.

On the morning of Saturday, August 17, two of the Society's engines in the Camborne area were inspected by members—the 90in Harvey pumping engine at Taylor's Shaft and the Beam Whim at East Pool—and both, with their houses, were found to be in excellent condition. Then, before and after the meeting, the Holman Museum was open to members. Besides the number of relics of engineering historical value (including the Rostowrack beam rotary, which was working) a display of photographs, drawings and documents relating to Cornish mines and engines had been arranged.

The annual general meeting was held in the cinema of the Holman Museum, with Lord Falmouth presiding. The hon. secretary/treasurer's report, which had been circulated to members, was adopted. Mr. A. T. Holman spoke of the progress of the Endowment Fund and stressed the necessity of building this up so that the work of the Society will be carried on long after present members have ceased to be interested in such matters. All officers and members of the council were re-elected, with additions. It was decided that the possibilities of holding the 1958 general meeting at the Severn Tunnel pumping station be investigated.

Following the business part of the meeting, Mr. Maurice Gregory read a paper on "Moorstone Boilers." Two blocks of granite from such a boiler, erected at Bullen Garden (Dolcoath) by Arthur Woolf, Jnr., in about 1770, have been presented by South Crofty, Ltd., and are now preserved in the Holman Museum. Mr. Gregory has done considerable research into the subject in collaboration with the Science Museum, South Kensington, and was able to describe the construction and operation.* As these boilers served Newcomen atmospheric engines, the steam pressure would not have exceeded about 4 lb per square inch. In this particular case, an attempt was made to utilise the waste heat from a copper roasting furnace.

* An article on "Moorstone Boilers," by Mr. Gregory appeared in our issue of August 2.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

CAMBRIDGE ARTS AND SCIENCE DEGREE

SIR,—May I reply briefly to Mr. Sigworth's attack on the classics in your issue of August 23, with a quotation which may help to put science and the arts in perspective. "The one says (in Wisdom's words): They that eat of me shall yet be hungry. And the other says: They that drink of me shall yet be thirsty. And both alike continually enlarge our curiosity and multiply our inlets to happiness."

D. A. OGILVIE

Peterborough, August 30, 1957.

EFFECTS OF HOB FORM ON TOOTH PROFILE

SIR,—I have read Mr. G. B. Thompson's article (page 262) with great interest and I think that from the practical viewpoint another matter may also be worth mentioning. Mr. Thompson shows that a straight hob profile differs from that required to produce involute helicoidal teeth in being "proud" near the tip and near the root. The discrepancy is, in most cases, of the order of a ten-thousandth of an inch and as it tends to produce teeth that are slightly "relieved" at tip and root its effect, if perceptible at all, is beneficial.

All this is on the assumption that a hob tooth cuts the gear blank wherever it touches it without any perceptible yielding of the body of the hob tooth or of the gear tooth. If the cutting edges are very sharp and the material to be cut is not excessively hard, this assumption is reasonable. If, however, the circumstances are such that the cutting forces produce appreciable deflection of teeth (in the plane of the normal section at the point of contact), then the gear teeth tend to be left "proud" at tip and root because the gear tooth bends easily when its tip is being cut by the hob, and the hob tooth bends easily when its tip is cutting near the root of the tooth. When the hob tooth is symmetrically set between two gear teeth it does not bend at all in the plane of the normal section because the gear teeth are pushing it in opposite directions in that plane. The relative deflection of hob teeth and gear teeth is therefore a minimum in that phase of engagement. This is a possible explanation of the "split-marking" sometimes seen on double helical gears, showing that the teeth are slightly thinner at mid-depth than they should be in relation to their thicknesses at other points nearer the tip or the root.

In short, the geometrical imperfection of a straight hob profile produces a beneficial departure from the involute form of the generated tooth, but it is so small that it may be masked by unavoidable imperfections in the cutting process.

W. A. TUPLIN

Sheffield, August 23, 1957.

Book Reviews

The Industrial Challenge of Nuclear Energy: Papers given at the First Information Conference on Nuclear Energy. O.E.E.C. European Productivity Agency. Price 30s. (from H.M. Stationery Office).

THE first Information Conference on Nuclear Energy was held in Paris last April. It was organised by O.E.E.C. in order to help business men, industrialists and managements generally to keep abreast of progress in the field of nuclear power. A wide range of subjects was covered in the five days of the conference, and twenty-seven papers were given on technical, industrial and economic aspects of nuclear energy. These papers are now reproduced in this book.

The marks of haste are apparent in the presentation of the book, which was printed in Switzerland. Haste may help to explain the abundance of mis-spellings and other injuries to the English language, which are by no means a usual characteristic of books printed in English in that country. Many of the mistakes are trivial, and, while they irritate, do not hinder comprehension. Thus, with the assistance of the context, one guesses that it is not "littoral" but "literal" that is meant when "litteral" is printed, and the skimming eye may scarcely notice that "requited" appears where "required" is obviously intended. Sometimes a statement is made that is apparently correct in spelling and grammar, but is nonsensical until a transposition, substitution or other alteration is made by the reader. For example, on page 49, we are told that there is about 500 times as much fertile material in the world as there is natural U^{235}, but are assured that all is well because "it is possible . . . to make fissionable materials form these more plentiful fertile materials." One is not halted for long by this sort of slip, but a sense of insecurity is bound to result.

Errors of such a verbal kind are not likely to mislead "business men, industrialists and managements generally," but on the more theoretical side the obscurities may be much more confusing. Here, surely, more time should have been devoted to proof reading. The misprinting of symbols is sometimes minor, as when neptunium is represented by N_p. In other cases, it makes the argument almost impossible to follow, except for those readers already familiar enough with the matter to correct the mistakes *en route*. To take a few instances: the radical sign, printed upright or on its side, occasionally appears on its own as an algebraic letter; quantities seem to be introduced without definition (or defined and never used again), though, in fact, it may only be that wrong symbols have been inserted in certain places; negative indices are sometimes printed in the same size and on the same line as bases; the sign Δ is used correctly, and then suddenly inverted where it should be upright; the subscript defining a letter is abandoned intermittently; a quantity $\delta k = \Delta k - \Delta k$ is said to give a reactivity, though the unhappy reader may be forgiven for thinking that it gives nothing at all; and so on.

These serious blemishes do not make it impossible to value the book. It does collect in something under 300 pages an assortment of papers covering many aspects of a very important subject. On the technical side speakers from many countries dealt with reactors, fuels, cycles, the first nuclear power stations, isotopes, mechanical and electronic equipment, and the like, while on the economic and political side there were papers touching on costs, geographical influences, the particular problems of Europe, the programmes of particular countries, and the activities of various international organisations. In fact, there is much of general interest, especially in the more descriptive matter, and the right sort of "syllabus" is covered to attract attention from the intended audience. It is a curate's egg of a book, and its virtues could be multiplied very simply, just by running through it and correcting the obvious errors. An index would also enhance its value.

The book is bound in paper covers. It is accompanied by a loose folding map, printed in black and white, which shows the distribution of nuclear establishments in Western Europe.

The Theory of Networks in Electrical Communication and other Fields. By F. E. ROGERS. Macdonald and Co., Ltd., 16, Maddox Street, London, W.1. Price 65s.

THIS book gives a thorough grounding in network theory. In accordance with the title, the outlook is that of the telecommunications engineer, nevertheless much of the material is useful to students in other fields. After an introduction to circuits under steady state and transient conditions, general network theorems receive very thorough treatment. Transient conditions are studied from the Fourier integral viewpoint and the mathematical results displayed on graphs are compared with oscillograms. Some non-linear impedances of practical importance are discussed. Network equivalances and two-terminal networks next receive attention, the precise meaning of network equivalence being carefully considered. Transmission lines, at both high and low frequencies, receive thorough treatment and there is some descriptive material which serves to connect the mathematical treatment with the actual practice of telephony and radio. Four-terminal networks, such as filters, are dealt with next, including the effects of losses in the components. The apparent anomaly of attenuation in loss-free components, which often troubles students, is disposed of. The concluding chapter deals in an up-to-date manner with measurements in linear networks. It is doubtful whether the pictures of apparatus in this chapter are useful.

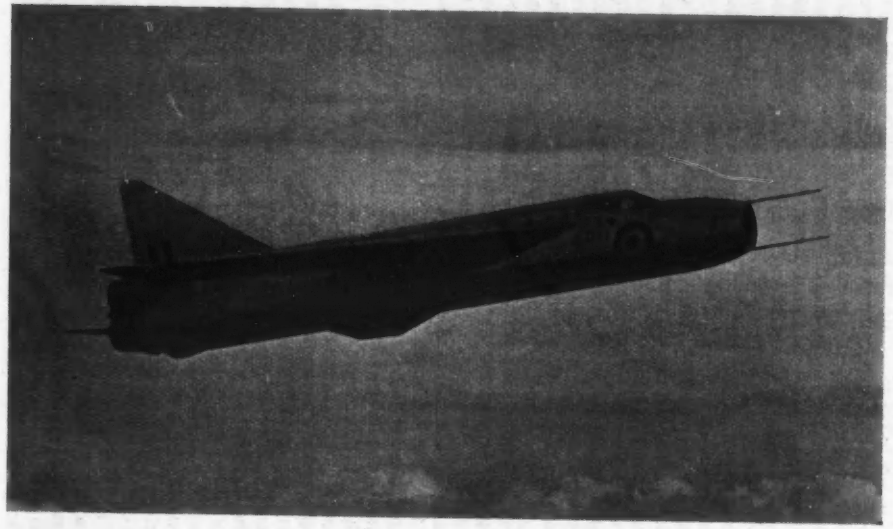
The book is specially suited to the outlook of engineering students because the physical significance of the mathematics is fully discussed and there are a great number of well-produced diagrams and graphs. There are many fully worked out numerical examples, all closely related to practice. An inevitable consequence is that the book is large and expensive, so that many students who would greatly profit by owning and using a copy may be unable to do so.

Books Received

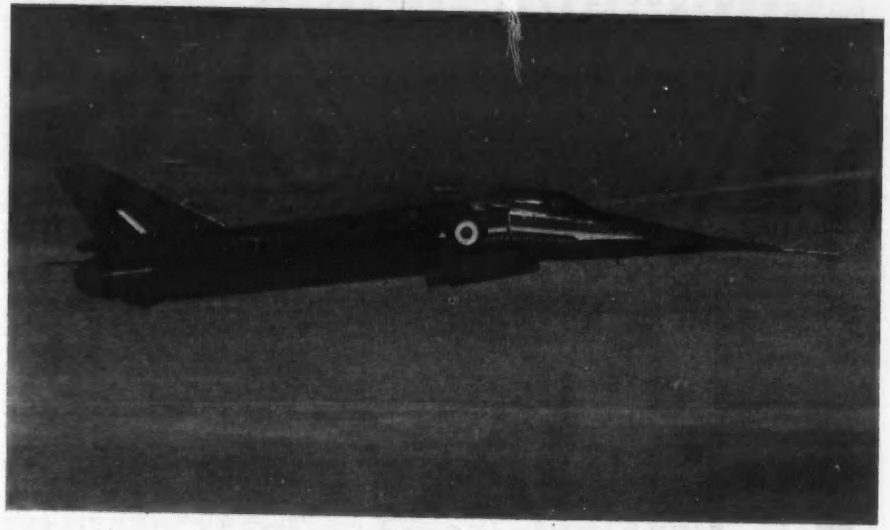
Behaviour of Metals at Elevated Temperatures. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 21s.

Servomécanismes et Régulation. Volume I. By H. Chestnut and R. W. Mayer. Dunod, 92, Rue Bonaparte, Paris (6e). Price 5.800 francs.

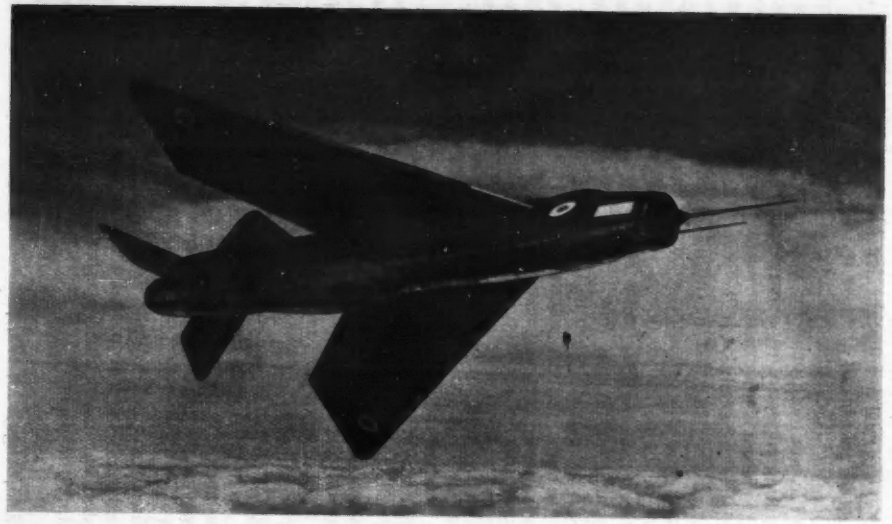
GREAT BRITAIN'S SUPERSONIC AIRCRAFT



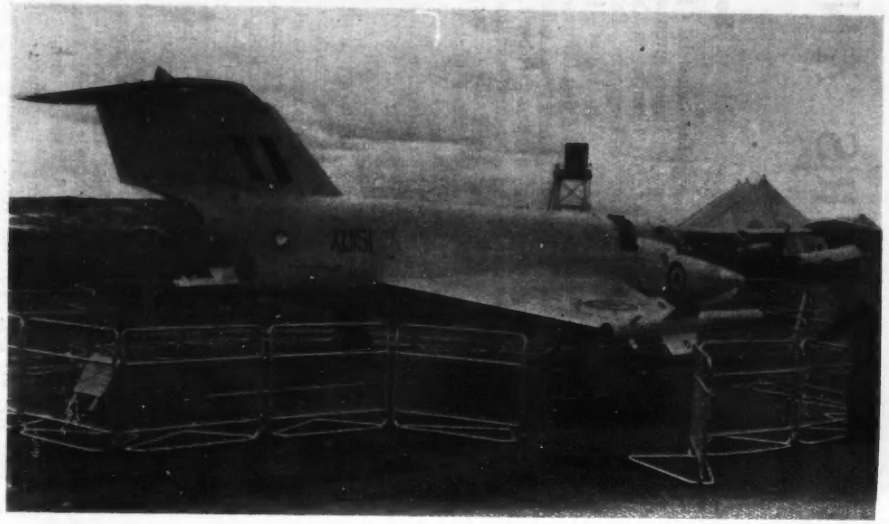
The English Electric "P.1.A." research aircraft: the further wing shows the greater tip chord of the modified, cranked, leading edge plan



The holder of the world's speed record, the Fairey "Delta" 2, demonstrates its hinged nose. Note the necessity to open the nose wheel doors, although the undercarriage remains retracted



The English Electric "P.1.B." all-weather interceptor prototype: the belly tank is quite different in shape from that of a "P.1.A." and bears a long shallow fin



The Saunders-Roe "S.R.53" mixed power plant interceptor project: on each wing tip there is a "Firestreak" missile

S.B.A.C. Display

No. I

The eighteenth Flying Display and Exhibition of the Society of British Aircraft Constructors commenced on Monday at Farnborough. It is open to the public to-day, tomorrow and Sunday. This year the exhibition includes many examples of missiles and components for them. Taking part in the flying display was the rocket-assisted aeroplane which recently broke the world altitude record, the "Scorpion-Canberra," seen here.

THE 1957 S.B.A.C. Flying Display and Exhibition introduces to the public several new aircraft, new engines, and new weapons. The one of greatest interest is, perhaps, the English Electric P.1.B., the only supersonic aircraft expected to enter Royal Air Force squadrons. On Monday the P.1.B made a full-power take-off, flame jetting from the tailpipe of the upper (rear) engine, before the flying display; it then made one pass, lighting the afterburners again to climb away and landed; this was presumably an unsuccessful flight test, since the aircraft did not take part in the flying programme. The appearance of the P.1.B. may be recalled from the illustration, showing it in flight, on page 348; examination of it on the ground showed that the supersonic air intake does not have a variable geometry, both lip and radome being fixed. The spine behind the raised cockpit canopy is packed with ancillary equipment, and one section of it appears to be dielectric. The nozzles have eight small segments around their periphery, which can impose a variable convergence, a similar nozzle being displayed on the Rolls-Royce stand; the flame holder appears to resemble that of the "Sapphire" on the P.1.A, comprising principally a single circular gutter. Many details mentioned in our description of the P.1.A. (July 5, 1957, page 19), remain unaltered; a model on display showed two "Firestreak" missiles carried low down below the leading edge. Since the "Swift" does not appear this year, the display proper included no combat aircraft with reheat.

The early part of the flying programme consisted principally of engine test beds. A pair of dark blue "Canberra" bombers mustered four different engines: the first was the experimental "Canberra" with a pair of Rolls-Royce "Nene" centrifugals and a de Havilland "Spectre" rocket, the second retained one of the normal R.R. "Avon" axials and had one de Havilland "Gyron Junior." The rocket test bed took off with a gout of steam, using hydrogen peroxide only in the rocket, and subsequently flew past with a golden kerosene flame standing on the nozzle, which was faired neatly into the belly of the aircraft. Another "Canberra" flew with two Bristol "Olympus" engines, representing a combination which until recently held the world altitude record, and was followed by the actual aircraft that broke the record, the "Scorpion-Canberra." (See page 353). It is now known that the two-chamber engine which we described as installed in a "Canberra" last year, was in fact the pre-production version of the "Double Scorpion," and that the "Scorpion" is a single-barrelled engine. The motor proper, which can be seen in the Static Exhibition, is enclosed in a stainless steel cuboidal box inclined at the rear end of the bomb bay and supported on a triangulated steel tube structure. The forward part of the bomb bay is occupied by the hydrogen peroxide tank, while behind the nozzles the fuselage has been recessed and skinned with steel to protect it from the hot gases: the aircraft has been seen with this area decorated with partly melted probes of solder and aluminium. This was otherwise an almost standard bomber, but numerous vortex generators of the familiar inclined fence type had been added to the upper wing well ahead of the ailerons: these are found to delay the onset of buffeting to a Mach number slightly higher at low altitudes and considerably higher at great heights. The bomber demonstrated its added thrust in steep climbs and manœuvres, flame licking back from the rocket as it was started or stopped. Among these varied "Canberra" flying test beds there appeared a Mk.8 bomber-intruder, which, having a cannon pack far back under the belly, carried its two bombs externally outboard of the engines. The remaining test beds were an Avro "Vulcan" with Rolls-Royce "Conway" by-pass turbo-jets, externally resembling the earlier pure delta bombers, and the reverse-thrust Hawker "Hunter," described and illustrated last year: the thrust reverser itself was displayed on the Rolls-Royce stand.

The helicopter demonstration was distinguished by the participation of a foreign airframe, the Sikorsky S.58, which, equipped with a Napier "Gazelle," is performing the prototype flying of the Westland "Wessex." This was the largest of the Sikorsky derivatives taking part, and confined itself to a fast fly-past. While it is known that the gas turbine renders the crew compartment much quieter, the spectator below the machine when it is flying low notices the addition of a high whine to the rotor thrash. The Bristol 173 twin-rotor machine appeared this year with twin fins with bendable trailing edges at the ends of a strut-braced tailplane. The Fairey "Ultra Light" again flew from the platform of a truck, taking off with the vehicle moving slowly and returning to the parked vehicle without any assistance from ground crews.

At this stage a display by aircraft of the Royal Navy took place, comprising formation fly-pasts by twelve Fairey "Gannet" machines, some stopping or starting one half of their Armstrong Siddeley "Double Mamba" engines, and formation aerobatics by five crimson "Sea Hawk" fighters, which emphasised some of the manœuvres by trailing smoke from their twin jet nozzles. They performed large loops and a barrel roll before completing their demonstration with a formation landing; when they flew away afterwards they unfolded their wings in unison as they taxied together to the runway.

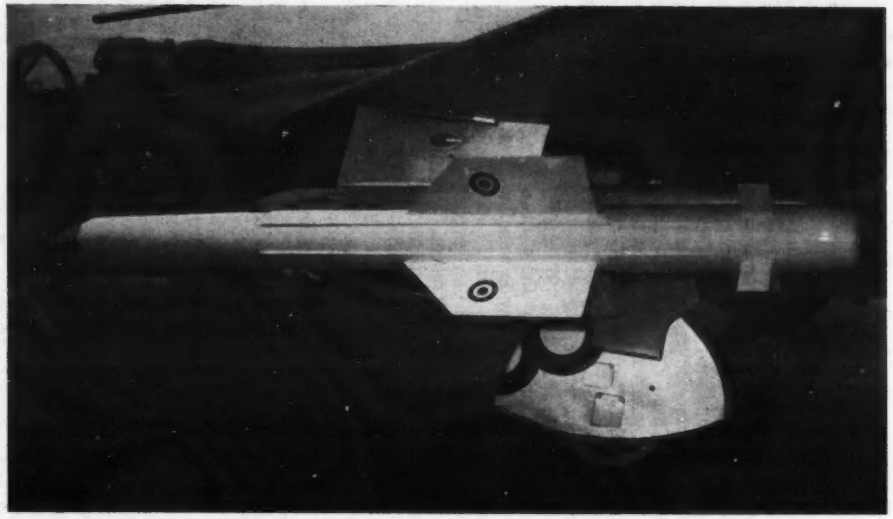
The passenger-carrying aircraft included the de Havilland "Comet" 3, now carrying out trials of "Comet" 4 equipment. Its "Avon" R.A.29 engines had noise suppressors, consisting of a few large lobes intruding into the circular periphery of the nozzle, the outer surface of the metal of each lobe being cooled by air entering at the front. Without a "Valiant" or similarly powered aircraft for comparison, no reliable assessment of the subjective effect of the silencing can be given, but the scream of the compressors seemed more noticeable in front of the aircraft, and the noise diminished quite quickly as the aircraft accelerated into its take-off. Three aircraft with Alvis radials then flew, the Handley Page "Herald" smoking voluminously at starting as if its "Leonides Major" engines had been inhibited, and the "Leonides" propelling the Scottish Aviation "Twin Pioneer" and the Hunting Percival "Pembroke." The "Pembroke" carried a folded Hunting "Harrier" four-seater portable military car, driven by an air-cooled four-stroke parallel twin above the back wheels, which drove fully loaded back up the runway.

Fly-pasts by twenty-seven Gloster "Javelin" all-weather fighters, twenty-seven Hawker "Hunter" fighters, two Vickers "Valiants" and two Avro "Vulcans" were part of the Royal Air Force participation. There were also formation aerobatics by a squadron of "Hunters," commencing with a large loop, penetrating an isolated cloud, and a barrel roll by nine machines in a symmetrical diamond formation. The five

GUIDED MISSILES ON EXHIBITION

A development test round for the Armstrong Whitworth "Sea Slug": the tie wires retaining the offset noses on the triple boosts show that each rocket casing is separate

An English Electric "Thunderbird" on its operational launcher: the long-span winglike aft control surfaces can be seen between the booster fins



A de Havilland "Firestreak" on a Hawker "Hunter": the shallow fairings at the wing roots probably carry electrical leads past the combustion chamber

The Vickers-Armstrongs "891" anti-tank missile part way out of its carrying case and launcher: it is controlled in flight by a human operator

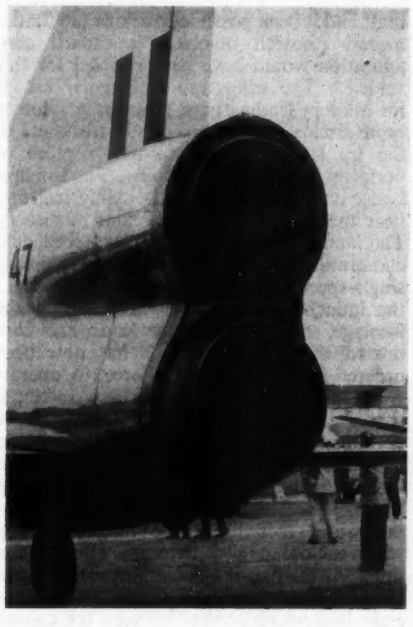
fighters on the leading edges of the diamond continued the display, changing formation as often as twice in a loop, and assuming the unusual formation of an X.

The next three aircraft to fly were all making their first appearance at Farnborough. The first was the Aviation Traders' "Accountant," a newly completed transport aircraft with two Rolls-Royce "Dart" engines. Grossing 28,500 lb, it is smaller than similarly powered aircraft such as the Fokker "Friendship" (35,000 lb) and the projected turbo-prop H.P. "Herald" (37,000 lb), and accordingly needs less extensive aerodromes. It is noteworthy that there has recently become known a Grumman design with a very remarkably similar appearance, using the same power plants, intended as a business transport. The "Accountant" in the form shown can be either a twenty-eight seat airliner or an executive transport, but a forty-seat machine can be built with a longer fuselage. It can be seen that the appearance of the machine is distinctive, and the reasons are not without interest. The original design was carried out on a principle known as tension-skin, and a fuselage built by this method has been displayed at Farnborough previously, but it is not now intended to use this technique in aircraft subsequent to the prototype. In this context the elegant compound curvature, contrasting with the cylindrical hulls of airliners newer than the "Constellation," can be recognised as a refinement, and subsequent fuselages will have a parallel portion, long or short, above the wing. The discontinuity in the profile aft of the freight door appears because it was originally intended to hinge the entire nose to give access for bulky loads, but this is no longer the case. The wing is distinctive in that, except for chordwise joints, there are no breaks in the lower, tension, surface. It is this feature that results in the distinctive shape of the nacelles, the engines being well away from the wing structure to allow a clear run for the jet pipe, and above it to ease the provision of propeller ground clearance. The resulting short main legs fold forward to bring the twin wheels in front of the leading edge, while the nose wheels retract backwards to sink part way into the fuselage; flying without wheel well doors, this was reminiscent of early retracting undercarriage designs which not only kept the retracted wheels the lowest part of the structure and in their normal plane, but also left them exposed. The airframe is claimed, as is appropriate for a prospective D.C.3 replacement, not only to have a long fatigue life, but also to fail safe, and can be inspected visually rather than radio-graphically.

The "Caravan" is the name given to the first product of collaboration between F. G. Miles, Ltd., and the Societé des Avions Hurel-Dubois, the H.D.M.105, which comprises a Miles "Aerovan" with a wing of aspect ratio 20·4 built on Hurel-Dubois principles. In flight it asserted its very low induced drag by commencing a steep turn as soon as it was 10ft or 12ft clear of the ground. This little experimental transport has accommodation for ten passengers and is powered by two Blackburn "Cirrus Major" engines. Based upon this machine is a larger version, the H.D.M.106, which with two Lycoming flat six engines of 580 h.p. will carry fifteen passengers. The remaining civilian newcomer was another Miles product, the "Student," with a Turboméca "Marboré" jet. This climbed over the aerodrome inverted and showed no lack of power; in heavily banked turns there was visible a suggestion of aileron snatch. When landed, the little trainer remained very firmly and stably on three wheels. An intriguing detail of this machine is the use of felt strip to give the effect of shrouding between fixed aerofoil and control surfaces. (A more complete account of the M.100 was given on page 879, December 16, 1955; it is illustrated on page 353.)

Military aircraft reappeared with the Folland "Gnat" and the Gloster "Javelin" Mk. 7. The all-weather fighter has had the "pen nib" tail pipe fairing replaced by a lengthened blunt fuselage: there is no sign of afterburners. The upper surfaces of the wings are heavily leavened with vortex generators, small ones near the leading edge and large ones nearer the ailerons, and the latter surfaces now have much less taper in section, the trailing "edge" being quite flat.

The Hawker "Hunter" Mk.7 two-seater, which made one very fast pass with vapour condensing over the cockpit canopy, then shared a display with four variously armed single-seaters, almost all of which smoked more or less heavily on acceleration. These



The "P.1.B." has variable-area nozzles, each with eight moving segments which tilt inwards as they move back. Notice the double wire trace for the braking parachute, recessed in the edge of the fuselage skin

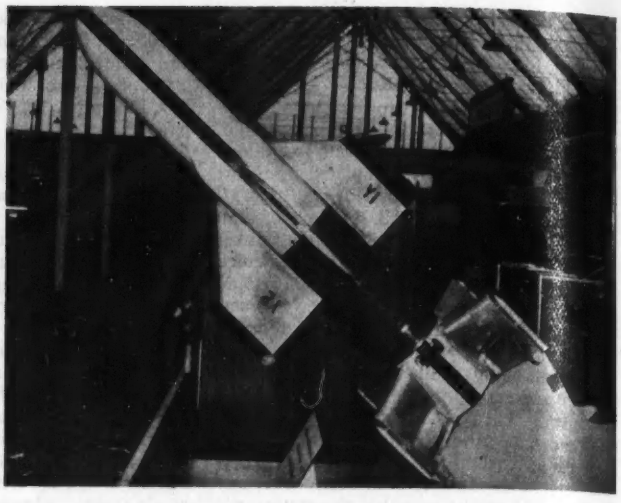
aircraft demonstrated braking parachutes on which the pilot parachute, instead of pulling the main canopy out of the pack, pulls the pack off the canopy: this technique is employed for sporting parachutes, as it reduces greatly the suddenness of opening and the consequent shock. The two-seater had a ribbon canopy on its main parachute.

The next performer was a production Vickers-Armstrongs Supermarine "Scimitar" with "super-circulation" by blowing compressor delivery air over the upper surface of the flaps from a narrow slot on the fixed part of the wing. The big strike aircraft took off with zero flap and landed with about 90 deg. flap: the approach was not conspicuously slow but the deceleration was great, suggesting that the flaps were depressed past the position of best L/D and that the blowing was cut on touchdown. The performance of the "Scimitar," or N.113, is described as transonic, i.e. little if any greater than Mach 1, but when it reaches the Royal Navy later this year it will give that service a faster machine than any in the Royal Air Force, even the same manufacturer's after-burning "Swift."

The de Havilland "Sea Vixen" which appeared this year had power-folding wings: it simulated an engine-out approach by coming in with the ram-air turbine extended below the fuselage. A characteristically gentle landing was made by the Handley Page "Victor" B.1, the machine running for some distance on the rear four tyres of each bogie before the walking beams were forced out of their extreme nose-up attitude.

The aerodynamic prototype of the Avro "Vulcan" Mk. II shows little change from the Mk. I, in the distant examination possible in this case. This is principally evident at the wing tips: the plan form appears to be the same as that of the revised Mk. I wing, but the leading edge now has a very small radius outboard and the under surface is noticeably concave. The ailerons now have a blunt trailing edge, and their operating gear has obtruded into large fairings with, apparently, cooling air inlets. These aerodynamic features are reminiscent of those of supersonic aircraft, which have conical camber and the maximum thickness very far back, so it may be inferred that compressibility effects first become evident at the tips. Unlike the Mk. I aircraft, the new machine had no vortex generators on the upper surface. Both versions floated far down the runway, giving the impression that the air brakes were of little effectiveness at low speed.

An English Electric P.1 A. research aircraft, with its straight-edged swept planform modified to give less sweep and lower thickness/chord at the tips, flew next. The demonstration included what were intended to be a straight run at Mach 0·98 and a complete circuit over the airfield in a 6 g turn: in each case the actual performance looked well up to expectation. The wing tips were frequently trailing sharply defined condensation trails, which was noticed with no other aircraft. When the big single-seater was landed, the brake parachute was streamed, a distinct delay occurring between distension of the pilot parachute and extraction of the main canopy. A research aircraft pure and simple, the speed-record-holding Fairey "Delta" 2, was followed by the Saunders-Roe S.-R.53, a prototype mixed power plant fighter which is now known as a research aircraft. The "Spectre" rocket was opened up before the take-off roll began, and seven shock diamonds were visible in the long exhaust flame: the "Delta" left the airfield in a steep, sustained climb, and performed a short and not spectacular flight. The detail design of the machine is unusual, the resemblance to a "Javelin" notwithstanding. The tail is most complicated (see illustration on page 353): the greater part of the tailplane moves bodily, but a part of it, larger than a tab and small for an elevator, moves separately, and segmental shrouds define its ends. The rudder has two tabs, the lower being quite possibly a control tab, while the upper has a flange on each side at its leading edge, slightly reminiscent of the control tab of a "Meteor" without auto-stabilisation, but appears to be restrained at the upper end. Slotted flaps and ailerons are apparently conventional. A row of pressure gauges on the outside of the fuselage show that nitrogen at 4000 lb per square inch is carried to provide an inert atmosphere for the fuel and oxidant tanks and to operate other services including, probably, control actuation on the rocket. As was to be expected, the fuel is stowed in the wing and the high test peroxide in the fuselage. A camera is prominent immediately in front of the windscreen, and "Firestreak" missiles nestle at the wing tips so neatly as to contrast strikingly with fighters designed for cannon combat.



(Left) The prototype "Accountant" twenty-eight-seat transport; notice the boxlike extension of the circular fuselage to which the wing is attached. (Right) This moving-wing rocket is described as a multi-purpose surface-to-air test vehicle; the spots on each wing define the pivoting axis

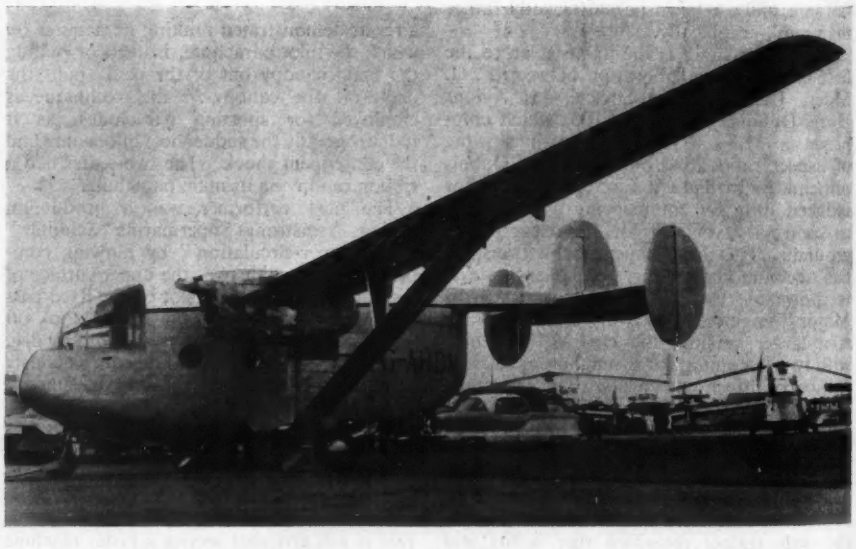
Guided Weapons

A part of the exhibition is set aside for guided weapons, and here and in the indoor exhibition are to be found a refreshing variety of armaments. We have previously described and illustrated the Fairey "Fireflash" (August 16 last, page 228) and the Bristol "Bloodhound" (August 30 last, page 295). However, it is now apparent that the nose of the "Bloodhound" is dielectric and not, as stated in our previous account, metal. On page 350 are illustrated three more missiles for defence against aircraft, the Armstrong Whitworth "Sea Slug," the English Electric "Thunderbird" and the de Havilland "Firesteak." The vehicle shown in the first case is actually an unguided control test vehicle, resembling the "Sea Slug," which is to be the Royal Navy ship-to-air missile. A sectioned exhibit, also of a development vehicle, shows the cylindrical body to be filled largely by two fuel tanks emptied by pistons driven in opposite directions by slow-burning charges; whereas continuously cast light-alloy cylinders have been used in this way by English Electric, this missile appears to be mostly steel. The bi-propellant liquid fuel motor is invariably adopted when extreme performance is required, and it may well be an advantage of ship-board installations that the firing of the weapon from very near its preparation bay allows a relatively complicated vehicle (unable to stand unattended indefinitely) to be adopted. It is known that the launcher is adjacent to a lock-follow scanner, so it can be assumed that the "Sea Slug" does not home. An unusual detail is that the very large complement of twelve boost rockets is mounted well forward and additional fin area is not needed during the boost phase. The nose is a cone and contrasts with the usual British ogive, while the severe rectangular aerofoils are also unusual.

The English Electric "Thunderbird," the Army anti-aircraft missile, shows strong evidence of the difficulties mentioned above. It is known that the Napier liquid-fuel rockets originally used by English Electric have now been superseded by a solid-propellant motor, and the combustion chamber for this must clearly be near the wing centre of pressure. The natural desire to avoid a long and inefficient tail pipe has robbed the control surfaces of moment arm and forced an enormous size upon them; the fact that they are working in the wake of the wings cannot be beneficial. It is difficult to resist the belief that, had it been possible to afford the fundamental research involved, a canard configuration would have been selected for this vehicle. The wings are rectangular except for a swept leading edge; it has previously been disclosed that aero-elastic weakness of the tip led to divergence and rupture of perfectly rectangular aerofoils. The fuselage is also unusual, being far from cylindrical and, near the wings, not even circular in section. The launcher is of a hitherto unprecedented elaboration, with a rapid but apparently single-speed traverse and a slow elevation; the launcher accepts the entire tail of the fuselage, and multifarious leads are conducted to it. This weapon has now been ordered for the Royal Air Force, to operate with the existing early warning radar; it shares with "Bloodhound" semi-active homing.

The four big boost motors of "Thunderbird" attach at the front to four points only, and these are naturally in line with the wings; there are, therefore, little hinged fairings which enclose the pick-up points after separation. At the rear the boosts are secured, presumably by frangible or explosive pins, to eight lugs which project between the control surfaces. Besides a missile and a complete vehicle on its launcher, there was displayed a test vehicle which had been fired and recovered by parachute three times.

Another projectile with the problem of centre of gravity travel is the "Firestreak," made by de Havilland Propellers, Ltd.; having no boosts and relying on its internal explosive charge for acceleration and sustenance, the air-to-air missile is forced to accept the cost in propulsive efficiency and dead weight involved in long, hot gas passages. It is, of course, an infra-red homer, and the nose has a series of optical flats which cause it to be likened to a sharpened pencil. Infra-red is, as is well known, attenuated by cloud, and where such weapons are used by all-weather fighters in the U.S.A.F., they are mixed with radar-guided missiles. The most notable feature of this missile is its size; it is 10ft 6in long. While it is obviously not sufficiently endowed with range to carry a nuclear warhead (which, in any case, could hardly be entrusted to a highly indiscriminate homing system) it is far larger than would be expected for a projectile to destroy individual aircraft. The reason can only be inferred; possible explanations are that the infra-red homing is prone to deception (some such weapons are strongly attracted to flares and similar extreme temperature targets), that the design was finalised at an unduly early state of achievement (a requirement for, say, liquefied gas cooling of the infra-red cell would burden the propulsion seriously), or that the difficulty of determining the range of

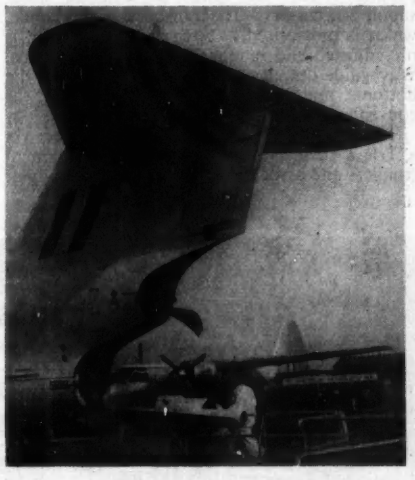


The H.D.M. 106 "Caravan" of Hurel Dubois and Miles (Aviation), Ltd., has an appropriate registration

the target by a passive system does not allow detonation at the optimum time. However, it may not be the case that the infra-red guidance demands a very heavy warhead ; it must be recalled that it is to arm such aircraft as the de Havilland " Sea Vixen," which cannot expect to have superiority in speed or height over their targets, and therefore that the length and time of flight are required to be very high.

Even the " Firestreak " is dwarfed by the Vickers " 888," an airborne missile with a slightly similar but more refined configuration ; it can hardly have been intended for any normal air combat role, but it is possible to speculate that an atomic warhead would require such a vehicle. This great weapon has, it is understood, been discarded, and the remaining Vickers missile, the " 891," is at the opposite end of the size scale ; it is an anti-tank weapon which, within the carrying case that acts as a launcher, weighs less than 40 lb. The missile is of a simple shape, with a conical nose and cylindrical body, and cruciform wings of an aspect ratio much less than unity, with control surfaces attached at their trailing edges. The case, 37in by 14½in by 14½in, carries the missile on a long rail, suggesting that the sustainer motor gives rather low acceleration ; a hole in the far end of the case emits the rocket exhaust. The cover of the case acts as a prop and also, probably, as aerial of the guidance transmitter ; a circular spool, on which the leads between launcher and controller are wound, fits within it and keeps the vehicle from sliding forward during carriage. The controller's equipment consists of a binocular viewer on a stand, together with a press button to fire. After a time of perhaps one second to warm up the control system, the operator can fire a series of missiles with only a few seconds delay between guiding one and firing the next in which time a fresh launcher is plugged in. Since there is no controlled aerial, this cannot be a beam riding guidance, but is almost certainly command guidance. The command signals would have to be extracted continuously from the attitude of the viewer ; if the computer can " remember " the attitude corresponding to " on target," fed in before firing, then it might be necessary for the operator to do no more than keep the missile in the sight (it is known that this is the manner in which U.S. Army radio-controlled weapons are operated). It is claimed that the accuracy and lethality will give a good chance of success against any armour likely to be met in battle.

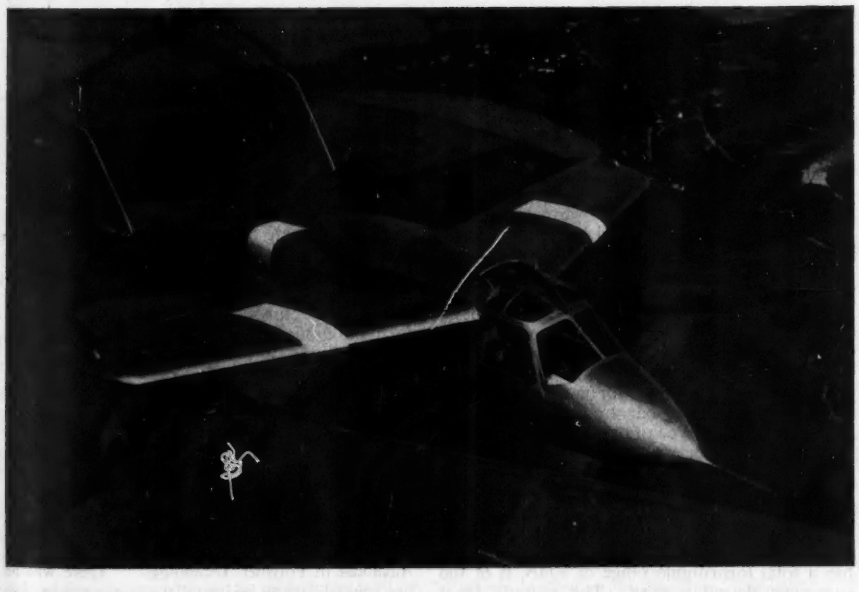
A much bigger and more complicated rocket of apparently similar conception is to be seen on the stand of Short Brothers and Harland, Ltd., and illustrated opposite. This is described as an experimental rocket vehicle, and is noteworthy as one of the exceedingly few British applications of the moving cruciform wing. The tail is also cruciform, the surfaces bisecting the angles between the wings and each fixed surface carries a flare to allow the operator to see the vehicle. The fore part of the body resembles



The complicated control surfaces of the " S-R 53 " can be seen : immediately above the dark line on the fuselage is the air brake

glass fibre, and near the wings fairings render it slab-sided. Each aerofoil is fabricated in the customary aircraft manner, and the section is a very conservative one, suggesting that the leading edge is well within the Mach cone, so that the speed can be little more than Mach 1. The role, if any, of the missile is unknown ; it was described as a ground-to-air test vehicle.

(To be continued.)



The Miles " Student " has an N.A.C.A. intake, with a pair of strakes bounding it, for the Marboré jet

World Altitude Record

THE world altitude record for heavier-than-air craft was raised last week by an aeroplane with a rocket motor. The new record of 70,000ft, which is supported by radio-altimeter observations made over the English Channel, was established by an English Electric " Canberra " B.2, with a Napier " Double Scorpion " and two Rolls-Royce " Avon " engines : the previous record was established by a " Canberra " with Bristol " Olympus " twin-spool jets. Controlled flight at such an altitude presents interesting problems, dominated by the low value of the air speed corresponding to the airframe Mach number limitation. At the high lift coefficients required in this case, the Mach limit will have fallen below the commonly quoted sea level value, and $M=0{\cdot}74$ would correspond to an indicated 140 knots. Since the minimum drag speed of a " Canberra " is 170 knots, it can be seen that extra thrust is required to enable the machine to be flown more slowly : in fact the thrust available was sufficient to provide a high rate of climb at the record altitude, the rocket having been energised at 40,000ft. Clearly, the power cannot be decreased in steady flight in this case, since the aircraft would immediately stall : it was necessary to nose over in approximately zero g and then trim the aircraft with great precision to avoid increasing the Mach number. The dive brakes are of little assistance in accelerating the descent while the indicated speed is so low. The turbo-jets were contributing little more than cabin pressurisation and in fact occasionally flamed-out without affecting the flight programme. The crew were protected against complete loss of pressurisation by partial pressure suits and pressure breathing. It is possible that the flights of this aircraft are the highest ever by a subsonic aeroplane.

Research on Internal Combustion Engines

THE annual report of the British Internal Combustion Engine Research Association, for the year ended March 31, 1957, stresses that the year was an important one for the Association, and a large amount of valuable research work was accomplished. The Association's financial position, however, is a matter of concern, the report states, even though a five-year grant is expected from the D.S.I.R., and industrial income from members has been increased. The amount of sponsored research carried out during the year was greater than before.

Seven technical panels are responsible to the Association's research committee. The fuel injection panel is an innovation, set up during the year under review ; it has surveyed the present stage of development of fuel injection equipment and listed several of the latest developments of Bicera systems. Considerable activity is recorded in the work of other panels. For instance, research on bearings and lubricants included endurance tests of bearings in which bearing pressures were increased in steps of 500 lb per square inch after 10,000,000 cycles at each step. To determine whether a bearing had a reasonably long life at pressures approaching the failing value found by this procedure, extended tests with a peak impulsive pressure were carried out, the results of which suggested a useful length of life at pressures of 1000 lb per square inch below the failing pressure as determined on the 10,000,000 cycle step-by-step basis. General research, in addition to the seven topics listed, included work on crankcase explosions, instrumentation and fuel rating.

Radar Transmitter-Receiver with 3MW Output

A NEW high-power 10cm radar transmitter-receiver designed for an actual output of 3MW has been introduced by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex. It represents a new approach to the concept of a packaged station to suit modern requirements for long-range radar applications such as early warning, air traffic control, air and coastal defence systems and meteorology. It is also stated to be suitable for surface-to-air warning systems installed in the larger naval ships. The equipment, which is known as the Marconi "SR1000," is on show at the S.B.A.C. exhibition, Farnborough, described on page 349 of this issue.

The "SR1000," complete with all auxiliary equipment (including power supplies, cabling, air and water cooling, and waveform- and performance-monitoring system), is contained in a cabinet measuring 87in by 73in by 40in (221cm by 186cm by 102cm). No h.t. or e.h.t. supplies are required externally and the cabinet is ready for connection to a three-phase a.c. supply. The compactness of the design is mainly due to the use of a hinged double-gate frame at each side of the cabinet. These frames, which are of open construction, carry all the small electronic components with their power supplies. As shown in the accompanying illustration, these hinged frames can be opened outwards to give access to the main transmitter-receiver assemblies in the centre of the cabinet. In the closed position the frames are recessed sufficiently into the cabinet to be enclosed by the front doors. Safety interlocks protect the operating staff.

Overload and phase failure protection circuits are incorporated in the equipment. These operate on a "three-shot" basis, automatically taking the transmitter off the air and attempting to restore it three times. In this way, if the fault is transient the equipment takes its own executive action to restore the service. The "SR1000" is designed for unattended operation with full remote control facilities. A comprehensive built-in monitoring system automatically and continuously monitors the more important parameters such as peak power, noise factor and standing wave ratio. Key waveforms are selected for display by press buttons.

The "SR1000" is suitable for use with the majority of standard display units as it provides both linear and logarithmic outputs simultaneously. It can have moving target indicator (MTI) facilities added for use in cases where the aerial size, pulse repetition frequency and aerial rotation rate will allow a useful degree of permanent echo suppression to be achieved.

Technical Design

The Marconi "SR1000" equipment is designed to provide an actual power of 2·5MW to 3MW in the S-band frequency range (2700 to 3300 Mc/s). Pulses of any length between 2·5 and 5·5 microseconds are generated at pulse repetition frequencies between 550 and 200 per second. The equipment is suitable either for free standing in a room (with the room air circulating through the cabinet as a coolant), or for connection to ventilating ducts, in situations where an increase in room temperature is undesirable.

Triggering is initiated either from a free-running 300 c/s internal oscillator or an external source which may be a pulse, a square-wave or a sine wave. The triggering pulse fires a thyratron, which, in turn, triggers a high-level modulator. The modulator uses a conventional d.c. charging circuit to charge a pulse-forming network. The charge is held by the network until it is released by the thyratron to be fed at an amplitude of approximately 10kV into the primary of a pulse transformer. The pulse-forming network is protected from the ill-effects of the accumulation of a negative charge (due to over-swing or magnetron arcing) by an over-swing circuit of novel design.

For transmission the pulse transformer steps up the applied voltage to the level necessary to feed the cathode circuit of a magnetron, causing the latter to oscillate at a frequency between 2700 and 3300 Mc/s during the triggering period. The peak power level of the oscillation is between 2·5MW and 3MW. The magnetron employed is designed to launch an H_{01} wave directly into the aerial waveguide system via a glass dome which is forced-air cooled. Between the magnetron and its associated electromagnet is a water jacket which forms part of a recirculation cooling system for which no external water supply is necessary. The transmission waveguide, which is pressurised at 30 lb per square inch, is pre-adjusted and requires no tuning operations. Waveguide output can be taken either from the bottom, middle or top of the cabinet, as convenient.

The r.f. pulses are fed to the aerial system via a T/R system, consisting of two 3dB binomial couplers and associated T/R cells. Each coupler consists of two lengths of waveguide coupled on one broad face by a series of slots, the net effect of which is to direct the r.f. energy into the aerial system, any breakthrough of energy via the T/R cells being dissipated in a waveguide load. Further protection is afforded by the incorporation of a passive T/R cell in the receiver waveguide arm. This cell is continuously fed with a "keep alive" voltage.

10cm Marconi transmitter-receiver with actual output of 3MW. The complete equipment including power packs and waveform and performance monitoring systems is contained in a single cabinet with hinged gate frames to house the smaller electronic components

Received echoes from the aerial pass through the T/R system into the receiver waveguide arm. This arm is not pressurised, being sealed off by an insulating window in the waveguide; it incorporates a mounting for a noise tube and terminates in a cross-bar transmission feeding into a coaxial-ring type of hybrid mixer.

The output from a klystron local oscillator is also fed into the mixer, the output from which is a balanced i.f. of 13·5 Mc/s, which is taken to a receiver head amplifier. The i.f. signal is amplified simultaneously in two amplifier strips, one linear and one logarithmic. The log. amplifier, which has a total logarithmic range of 80dB, is of the successive detection type. The outputs from these two amplifier chains are rectified and passed to associated video amplifiers which provide linear and logarithmic video signal outputs for feeding to radar display systems.

Automatic frequency control is initiated by mixing sample outputs from the aerial waveguide and the local oscillator, the resultant output being amplified and applied to a Foster-Seeley discriminator. This discriminator detects any shift in frequency from the normal i.f. and produces a pulse output whose amplitude and polarity are dependent upon the frequency shift. After passing through a stretching circuit the pulses emerge as a sawtooth waveform, which is positive-going if the i.f. is below 13·5 Mc/s and negative-going if it is above 13·5 Mc/s, and has an amplitude proportional to the error. This sawtooth waveform is then integrated to provide a control voltage for the local oscillator.

Monitoring Facilities

A characteristic of the "SR1000" equipment is the comprehensive monitoring system. General monitoring facilities are provided by an indicating unit mounted on the right-hand gate-frame. The time base circuits of this unit are triggered by a pulse which occurs 3 to 5 microseconds before the transmitter pulse. All essential modulator and transmitter waveforms can be selected by push button; simultaneously a diagram of the waveform to be expected is displayed on an escutcheon above the indicating unit c.r.t. The appropriate sweep speed (10 microseconds or 30 microseconds) is also selected by push button. Provision is also made for the viewing of the linear and log. receiver outputs on an "A" scan display. Additional sweep speeds representing 25, 100 and 200 nautical miles are provided for this purpose.

Calibration markers at either 1 microsecond intervals, or the equivalent of 5 nautical miles are incorporated, selection of the appropriate marker being made automatically when the sweep speed is selected. Markers can be displayed by pressing the appropriate button.

The monitoring system provides for the display of the magnetron spectrum, the superimposed display of magnetron and local oscillator spectra for tuning purposes and the display of i.f. response and a.f.c. discriminator characteristics, selection being made by push button.

The receiver noise factor can be monitored continuously by means of a computer incorporated in the equipment. Automatic sampling is employed in conjunction with the computing circuits, which use "Dekatron" cold-cathode counting tubes. The computer is also used for the computation and display of standing-wave ratio and peak power measurement, the resultant information again being displayed on "Dekatron" tubes. Such tubes are also used for continuous monitoring of the general power units.

Advances in Polymer Technology. The Institution of the Rubber Industry and the Plastics Institute are holding their first joint conference on Thursday, February 27, 1958, probably in the building of the Institution of Civil Engineers, Great George Street, Westminster, S.W.1. The subject will be "Recent Advances in Polymer Technology." There will be two general lectures and parallel sessions of papers in the morning and afternoon.

Radio Telescope at Malvern

THE Royal Radar Establishment recently completed the installation of a radio telescope at Pickersleigh Road, Malvern. It was commissioned in January, 1956, for radio-astronomical observation and advanced research on microwave propagation. The paraboloidal reflector is 45ft in diameter and is made almost entirely of aluminium alloy extrusions and sheet. It is mounted on an old radar turning mechanism

The 45ft radio telescope, installation of which was recently completed at Malvern

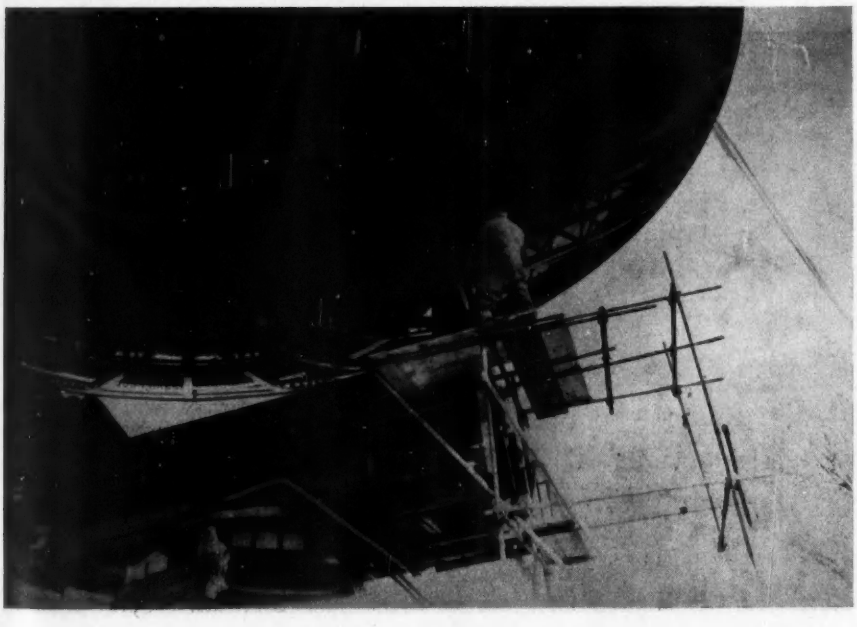
that has been raised on a tower, and can move through 360 deg. in azimuth and 80 deg. in elevation. Not a large radio telescope by modern standards, it is the only steerable instrument in Great Britain designed to work at wavelengths down to 10cm.

It is claimed that, as a result of care and improvisation, the cost has been kept down to something like £10,000. Thus, the support for instruments at the focus is a steel telegraph pole bought from the G.P.O. The principal expenditure has been on the aluminium alloy reflector, which replaces one having a diameter of 25ft. It was calculated that a maximum weight of 4 tons could be allowed for the replacement reflector, and light alloy was therefore adopted for its construction.

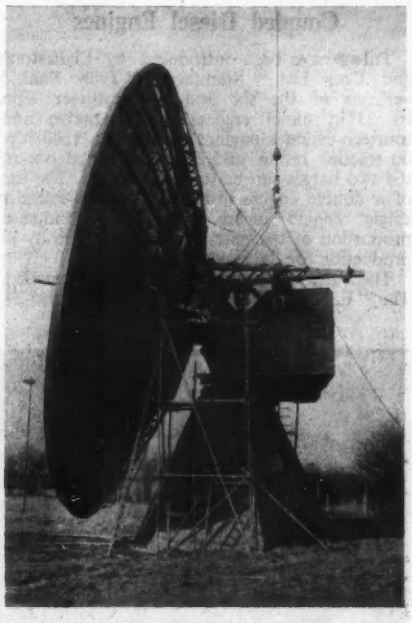
The specification called for the maintenance of paraboloidal shape within a tolerance of $\pm\frac{1}{4}$in under all operating conditions. This implied manufacturing tolerances from $\pm\frac{1}{16}$in at the centre of the bowl to $\pm\frac{1}{8}$in at the periphery, since the equipment was required to function in all positions (*a*) at ambient temperatures ranging from 4 deg. to 25 deg Cent., with temperature differences across the surface (due to partial shadowing) of as much as 35 deg. Cent., and (*b*) in steady winds of up to 30 m.p.h. The reflector was designed to withstand steady winds of up to 60 m.p.h. from any direction, and ten-second gusts of up to 110 m.p.h. Another design condition to be met was 2in of ice or 12in of snow on all upward-facing surfaces. Aluminium alloy to British Standard H10–WP was used for the whole reflector structure, which was riveted and bolted together. Chobert rivets were extensively employed. All of the alloy was treated with etch primer and an iron oxide undercoat. The bearing trunnions are of mild steel: to avoid trouble at junctions, the steel was sprayed with aluminium before assembly.

The pointing accuracy of the servo-controlled mounting is said to be unusually high, and the gearing is said to be precise within about ±30 seconds of arc, both in azimuth and in elevation. A compensator, driven by a synchronous motor, automatically accounts for the rotation of the Earth during tracking. An additional safety measure, not yet completed, will be a control from the anemometer (visible on the upper edge of the bowl in one of the illustrations) which will automatically level the reflector when the wind speed exceeds 30 m.p.h.

The telescope is essentially a large directional aerial connected to a radio receiver. Radiation over a wide band of wavelengths, emitted by stars, interstellar gas or other matter, is collected by the aerial and thereafter amplified in the usual way. The instrument is being used to determine deuterium (heavy hydrogen) in the galaxy: it has been estimated that deuterium is not more than 0·05 per cent of the hydrogen content.



After separate assembly on the ground, the bowl was lifted into position on the mounting. The securing of the reflector is shown under way in this view of the work



Counterweight arms are here being fixed to the reflector. The time from the conception to the completion of the telescope was about sixteen months

CONSULTANTS AND CONTRACTORS

The reflector was designed jointly by the Engineering Department of the Royal Radar Establishment, the consultants, Messrs. Jenkins and Potter, and Precision Metal Spinnings (Stratford-on-Avon), Ltd. Advice was received from the Aluminium Development Association and from the Military Engineering Experimental Establishment, Christchurch. Aluminium was supplied by the British Aluminium Company, Ltd., and fabrication was by Precision Metal Spinnings (Stratford-on-Avon), Ltd.

Molybdenum Disulphide Engine Lubricant

THE use of molybdenum disulphide as a lubricant in conditions of temperature and pressure precluding hydrodynamic lubrication is familiar in industry. By using a much smaller particle size than prevails in industrial lubricants, a molybdenum disulphide additive for engine oils has now been evolved by Rocol, Ltd., Swillington, Leeds, and named " Molyspeed." The dispersion is fine enough to resist settling out with time or extraction by filters, either full-flow or by-pass. Tests comprising 2000 miles running with a car engine showed that about 75 per cent of the molybdenum disulphide was deposited on the exposed metallic surfaces ; with detergent oils more remained suspended than with straight oils, but correspondingly less was extracted by the filter, presumably due to lessened coalescence.

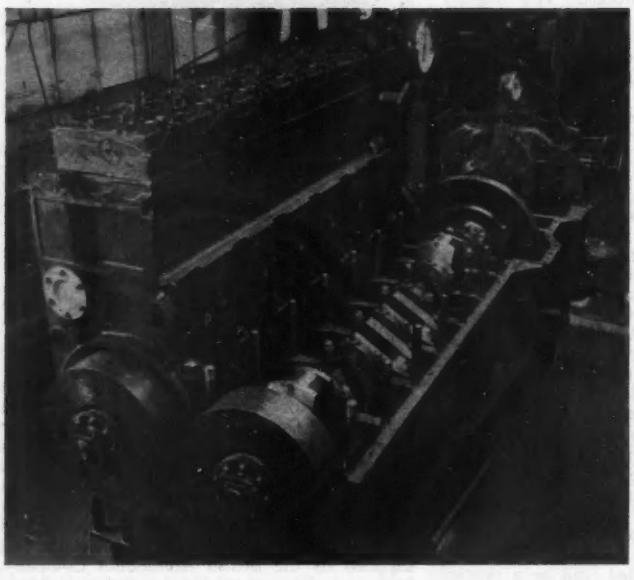
In addition to the field trials above-mentioned, a series of tests were carried out with 412 c.c. J.A.P. Model 5 air-cooled petrol engines, with a peak speed of 2200 r.p.m. The reduced friction with molybdenum disulphide added to a straight premium grade mineral oil resulted in the power of this lightly loaded engine—rated b.m.e.p. 64 lb per square inch—increasing 16 to 18 per cent at full speed, while the best fuel consumption dropped from 0·64 pints per brake horsepower hour at 1600 r.p.m. to 0·57 pints per brake horsepower per hour at 1800 r.p.m. The ability to run continuously also improved : twenty-two stoppages due to sticking of the exhaust valve in a 500-hour run at rated output were reduced to one with additive, and two stops to remove deposits from the exhaust valve were reduced to zero. The carbon deposition under the piston crown was also reduced, indicating prevailing lower temperatures.

It is considered that the deposit of molybdenum disulphide on the working parts will last as long as one charge of oil : it is, therefore, recommended that at every alternate oil change 6 per cent by volume of " Molyspeed " be included.

Coupled Diesel Engines

THERE have been introduced by Blackstone and Co., Ltd., Stamford, "Twin Bank" versions of the six and eight-cylinder 8¾in by 11½in diesel engines. The twelve and fourteen-cylinder engines give up to 1540 h.p. on traction rating, and are so built that one of the two halves can be operated alone. The use of a double engine instead of a multi-cylinder single engine means that a preponderant proportion of the parts required are already in production for the single engines.

The basic engine should perhaps be recalled. The "E.V." series was described on June 29, 1951, page 871 : since that date the output of the turbo-charged engine has been raised from 60 to 66 b.h.p. per cylinder at sea level, the output at and above 5000ft remaining the same. The "E.R." series, which is rated at 750 instead of 600 r.p.m., differs in having aluminium silicon alloy pistons with parallel-section rings instead of cast iron with taper rings (in both cases chrome-plated rings are now used, and the chrome facing of the cast iron liners has been discarded) : the brake mean effective pressures are the same in each series, while the increased speed leads to the Napier turbo-blower of the "E.R.S." giving 4½ lb boost against 4 lb for the "E.V.S." The lower speed engines are cleared for class "A" and some class "B" fuels, the higher speed models for class "A" only.



A twelve-cylinder twin-bank engine in course of erection : notice the overlapping flywheels and, beyond them, one of the output pinions. While rotation is the same in each case, the blocks are handed to bring both timing sides outwards

The coupled engines are in essentials two self-contained units on a common sump : all the ancillaries are similar to those used on six and eight-cylinder engines, but the lubricating oil pressure passages are coupled, and must be isolated if one half only is to be run. The racks controlling the C.A.V. injection equipment are set in harmony and locked to move together as the means of sharing the load between the two. They have in common a sump extending up to crankshaft centre line level, as seen in our illustration, to which the cylinder blocks are clamped : these parts are normally cast, but, if weight is critical, can be fabricated—this is usually confined to traction applications. Dry sump lubrication is available for marine purposes. The crankshafts run in the same direction, the camshafts being identical, and there is no need for any phase relationship to be preserved between them. The Blackstone resilient coupling, which is claimed to enable their engines to be harnessed without any consideration of the torsional flexibility, damping, or excitation of the load, is used in these engines to protect the coupling gears from transient loads. The coupling consists essentially of an annular disc driven at its outer circumference by the engine, and bonded by rubber to the sides of a wide, shallow Vee groove in the output member : the permissible travel of this coupling is 5 deg. Errors in angular alignment can be accommodated also, the driving disc being mounted on numerous small pins and bushes, grease lubricated, which do not restrain it axially. Within the driving disc and rotating with it are a number of discs of 0·7 per cent carbon steel, the material of circular saws, and inter-leaved between them are discs, either bronze or the same material, secured by axial serrations to the output. The space occupied by these discs is sealed and filled with grease or a silicone oil, thus affording viscous damping of the motion of the rubber in shear. This coupling is described as a nodal damper, on the grounds that the flywheel is usually the node of a torsional oscillation. Its natural frequency may be in the running range of three-, four-, or five-cylinder units, but is below that of six-, and eight-cylinder engines. The gearbox is exceedingly simple, comprising three straight-tooth gears embraced by bearings identical with those of the crankshaft journals : a separate oil pump and heat exchanger is provided to allow a lubricant differing from the engine oil to be used. The sizes of driving and driven wheels can be altered to give, without change of centres, ratios between 1·57 and 0·71, i.e. outputs between 1200 and 425 r.p.m. If an emergency, or the need to proceed at greatly reduced power for a long period, arises, it is a matter of a few hours' work to remove the screws securing the coupling to the gearbox input flange : a coil spring bearing against the coupling through a ball bearing then holds them apart. For marine propulsion purposes where the delay in uncoupling in case of a breakdown would be intolerable, friction clutches can be provided, affording also the facility of bringing in the second engine while running. The two governors normally share the force needed to move the fuel racks, so that small discrepancies in their behaviour do not cause them to oppose each other, but when one engine is to be disengaged the balancing linkage must be locked and the appropriate governor must be isolated.

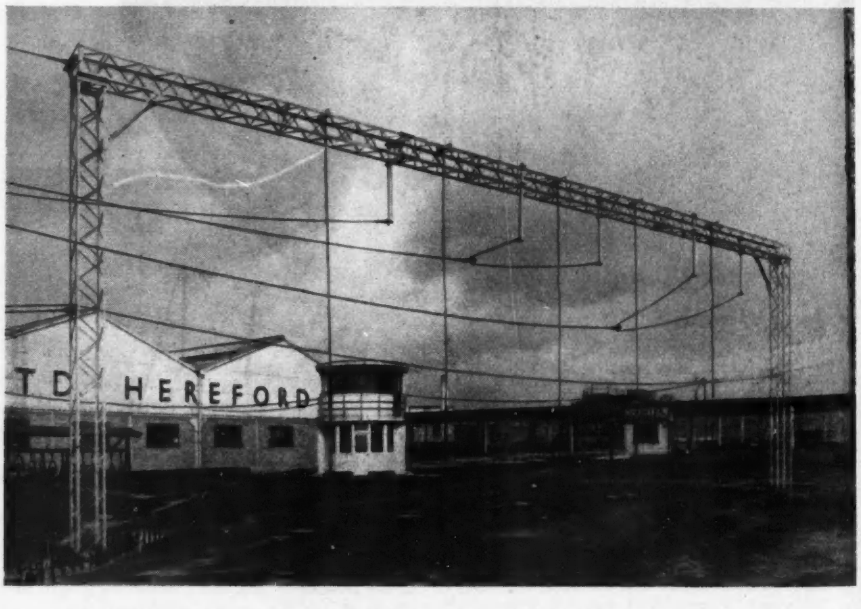
The gearcase is designed to accept flange-mounted generators or reverse/reduction gears, with the entire unit installed on anti-vibration mountings. Up to 50 per cent of the power of the coupled engine can be taken from the front of either crankshaft, where there is a large hydraulic torsional damper. For traction applications, the engine speed may be taken up to 800 r.p.m. to obtain 1540 h.p. from the sixteen-cylinder plant—for marine propulsion 1190 h.p. is available at 750 r.p.m. with gear ratios up to 3, while ratios of the order of 7 are contemplated to allow direct substitution for ungeared engines—and industrial and auxiliary installations 1320 h.p. can be taken to a 1000 r.p.m. (50 cycle) or 1200 r.p.m. (60 cycle) alternator. The engines can be run down to 250 r.p.m. We are informed that the fuel consumptions are, within B.S.S. tolerances, those of the original engines, i.e. 0·372 lb per horsepower hour normally aspirated and 0·365 lb per horsepower hour supercharged.

Portal Structure for Overhead Equipment on 25kV Railway Electrification

A NEW design of portal structure to support the overhead conductors and associated gear for railway electrification at 25kV, 50 c/s, has been developed by the traction department of British Insulated Callender's Construction Company, Ltd., to the requirements of the chief electrical engineer and chief civil engineer, British Railways Central Staff, B.T.C. The structure is built with angles as the main members and rod bracing welded to the toes of the angles. After fabrication the complete structure is galvanised.

Earlier railway electrification schemes in Great Britain carried out at 1500V direct current required heavy steel support structures to carry the large section wires and associated equipment. With the 25kV, 50 c/s system of electrification, however, smaller wires can be used to carry the reduced currents, and the support structures can be lighter. At the same time, to ensure good current collection, the wires must be kept at constant tension by means of balance weights, throughout most of the operating temperature range. As the temperature varies the wires move along the track and thus apply a torque to the bridge of any portal structure used to support them. Provision must be made to withstand this torque.

In designing a structure to meet these conditions the main considerations were lightness, economy in manufacture, avoidance of obstruc-



New welded steel portal structure for British Railways overhead 25kV, 50 c/s system electrification, rigged for load testing

tion to the sighting of signals and good appearance. Such a structure has been built and tested at the works of Painter Brothers, Ltd., Hereford, as illustrated here. It is designed for use over five tracks, has a span of 71ft and is fabricated from 2in by 2in by $\frac{1}{8}$in angles and $\frac{3}{4}$in diameter rods jig welded to the angles. This structure weighs $1\frac{1}{2}$ tons, whereas the equivalent structure for 1500V d.c. electrification would have weighed about $2\frac{1}{2}$ tons.

For the tests, loads typical of those that would be caused by the equipment and by wind were applied to the structure. There was no undue deflection and no permanent "set" when loads of one and a half times the maximum working loads were applied, and there was no failure when the loads were increased further to two and a quarter times the working loads. Our illustration shows the structure just before the loads were applied.

We learn from the British Transport Commission that this form of structure, incorporating jig welded rods, will be a standard type for use when three, four or five tracks are spanned and it will be used in large numbers in the main line electrification at 25kV, 50 c/s for British Railways.

Cellular Embankment

SUBSIDENCE caused by brine pumping has been experienced at the Elton viaduct, which is between Crewe and Sandbach, on the main line to Manchester, of the London Midland Region of British Railways, since it was constructed in 1842. Between 1892 and 1956 a total subsidence of about 16ft was recorded, fluctuating from 2in to 9in in a year, the yearly average being 8in. It is thought that subsidence of this kind will continue indefinitely.

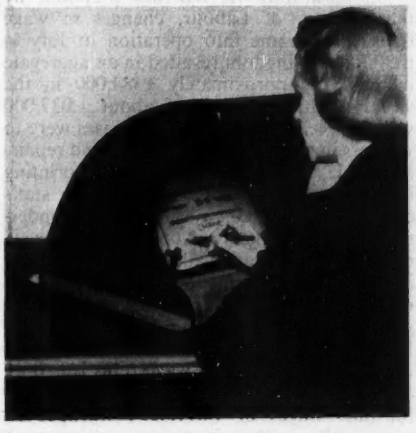
The first of our illustrations depicts a steel bridge crossing a stream at Elton, and shows the strutting which had eventually to be added after successive heightenings. Since the structure is tilting slightly, as well as sinking, it was considered that successive heightenings of the bridge had been carried on practically to the limit, and with the advent of electrification, with overhead gear on the line, a more amenable solution was sought.

The resulting design is shown in the second illustration, which is an impression of a model. The cellular construction shown will consist of a number of reinforced concrete pipes, each with an external diameter of 5ft, curtailed in total length in the higher positions so that the outline of the embankment is approximately followed. The lowest pipes will rest on a reinforced concrete raft, and all the pipes are to be concreted together and reinforced, since it is intended that the block thus formed will behave monolithically. As the block sinks it is intended to add more pipes at the top, and to lengthen the lower ones so that they will still extend across the full width of the embankment. Thus, however far settlement continues, there will still be passage for the stream. On each occasion when such rebuilding is necessary, the permanent way will be reinstated over the top in a conventional manner.

The ground conditions at this site are poor, and the new structure will permit some lowering of loading under the existing brick walls. But the main idea behind the design, we understand, is to accommodate conveniently the adjustments necessary because of perpetual subsidence.

Two-Way Visual Communication System

A TWO-WAY visual communication system, known as "Deccafax," has been developed and introduced by Decca Radar, Ltd., 1–3, Brixton Road, London, S.W.9. It provides immediate exchange of visual and aural information between



The master unit shown here serves as transmitter and receiver in the "Deccafax" two-way communication system, over distances up to 2000 yards without amplification

interconnected points in a closed circuit communications system. The equipment transmits and receives television-style facsimile images (line or half-tone) of illustrations, plans, written messages, 35mm slides or films. It also serves as an internal broadcasting system whereby information in sound and vision can be relayed to modified television receivers connected in the circuit.

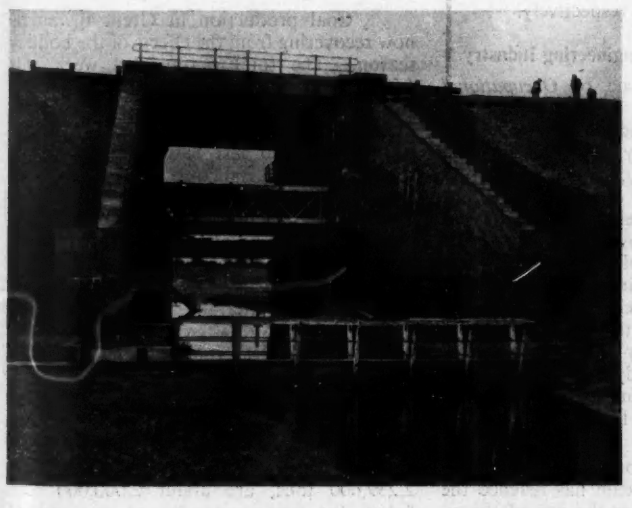
The basic arrangement for communication by "Deccafax" between two points consists of two master units connected by a low-loss co-axial cable. A typical master unit is illustrated here. Essentially, it consists of a specially designed cathode-ray tube made by Ferranti, Ltd., the screen being coated with phosphors selected to give the required characteristics for this application. A photo-cell is built into the top of the hood, which shields the screen, and "flying spot" scanning techniques are used for facsimile transmission of visual information. Monochrome pictures are transmitted (405-line) by placing transparencies on the screen of the "transmitting" master unit, or by using 35mm slides in a special projector built into its hood, or by writing information on the screen of the unit, for example, with a "Chinagraph" pencil. A facsimile image of the transmitted picture is then reproduced on the screen of the "receiving" master unit. A single transmit/receive switch enables the direction of speech and picture transmission to be reversed between the two master units. Any number of master units can be connected into the system if required.

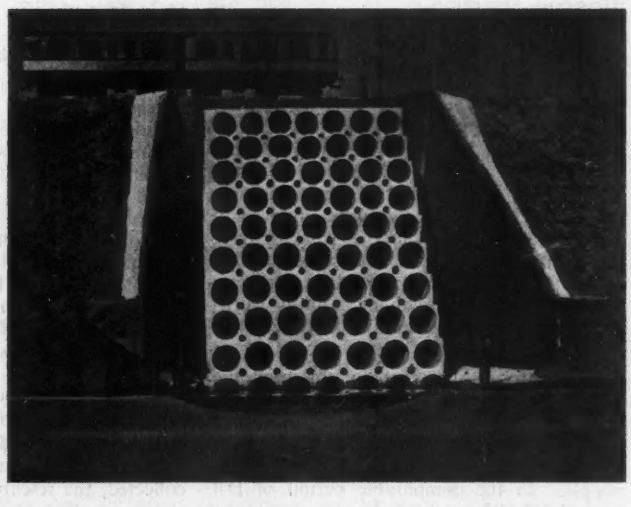
For internal broadcasting one master unit can supply one or more modified television receivers connected in the closed circuit. At an airport terminal, for example, announcements can be routed from a master unit to any number of television receivers, interrupting the normal entertainment programmes. With a suitable arrangement of the circuit visual information from two or more master units can be mixed and displayed on a single receiver. Alternatively, an announcement can be routed to one particular receiver alone. Such routing can be effected easily by conventional switching means.

The system is inherently suitable for collating information from a number of sources for visual display as required. A number of master units can be connected to feed various kinds of information to a central receiver for collation and, if required, enlargement on a viewing screen. A controller at this collating centre can communicate with any or all of the remote units through a control extension. By filtering the information from these sources the operator can ensure that the main display shows only the information required at any given time.

Each master unit is mounted on a steel desk. A hinged metal grille at the base of the unit gives access to the television-style controls for contrast, picture "hold" picture height, &c. The coaxial cable connecting the master units and receivers allows for transmission, without amplification, over distances up to 2000 yards. This distance can be extended by using simple amplifiers. The receivers used for broadcast application of the system are "Decca" standard television receivers slightly modified to accept the closed circuit input, in addition to the normal programmes.

EPOXIDE RESIN TOOLS.—A new information sheet published by Bakelite, Ltd., 12–18, Grosvenor Gardens, London, S.W.1, describes four methods of manufacturing epoxide resin tools. These methods cover small and lightly stressed tools of intricate contour, large lightly stressed tools of simple contour such as checking and assembly fixtures, and highly stressed tools, particularly press tools for metal forming. The sheet sets out in detail all the relevant information on epoxide tools, including the materials required, the preparation of materials and moulds, and data on cured epoxide resin based castings and laminates. It also lists suppliers of ancillary materials and equipment.





(Left) Existing bridge at Elton, showing steel and timber strutting. (Right) Model of proposed cellular structure which will replace the bridge, and will be heightened as subsidence occurs

Industrial and Labour Notes

The Trades Union Congress

The eighty-ninth Trades Union Congress is in session at Blackpool this week. It opened on Monday morning when Sir Thomas Williamson delivered his presidential address.

In his address, Sir Thomas spoke about industrial relations in this country, saying that although the total time lost by strikes this year would exceed that for any year since 1926, there were few industrial countries which had a better record than Britain for peace in industry. Trade unionists, Sir Thomas continued, must honour agreements and use established machinery to make new ones. In industrial matters, Sir Thomas added, he had no time for the minority who ran away from responsibilities by joining unofficial movements to circumvent the official constitutions and policies of their organisations. To safeguard unity and democracy in the trade union movement and to maintain prestige in the community, the unions must condemn and restrain those who organised unofficial movements and unofficial strikes. Men should not be called upon to strike, Sir Thomas commented, except under constitutional trade union authority, and only when all other methods of negotiation had been exhausted. Every dispute must end in a settlement, and the trade union movement should work for a solution before a stoppage took place, even though it might call for " patience and forbearance often in the face of provocations."

Later in his address, Sir Thomas was critical of the setting up by the Government of the independent council to survey incomes, prices and productivity. He claimed that its terms of reference did not specifically cover investment. It was difficult to see, Sir Thomas remarked, what new facts or what new comments the council could produce ; there were already enough " peddlers of economic panaceas." It could only be assumed, Sir Thomas said, that the Government expected the council to speak with such weight that its pronouncements would lead people to reconsider their policies, but he wondered if that was likely to happen. Stable prices, he continued, could not be combined with full employment by leaving our fortunes to the push and pull of market forces. Greater industrial efficiency was the only answer to rising costs and prices.

Industrial Disputes

A report on industrial disputes, published in the *Ministry of Labour Gazette*, shows that there were 184 stoppages of work which began in July and nineteen which had started earlier and were still in progress at the beginning of the month. In these 203 stoppages, 131,300 workpeople were involved in July, the aggregate number of working days lost being 871,000. In the corresponding month last year, there were 164 stoppages through disputes, involving 58,400 workpeople and resulting in a loss of 285,000 working days.

In the first seven months of this year, the aggregate number of working days lost in the United Kingdom through stoppages arising from disputes was 7,829,000. There were 1706 stoppages, involving 1,163,200 workpeople. In the comparable period of last year, 1,401,000 working days were lost by 341,200 people in the 1536 stoppages of work which were reported to the Ministry. The increase in the number of working days lost this year is accounted for, of course, by the strikes in the spring in the engineering and shipbuilding industries. In the seven-month period reviewed by the Ministry, 4,980,000 working days were lost through strikes in the engineering and shipbuilding industries, compared with 139,000 working days in the corresponding period of 1956.

Wage Rates and Average Earnings

According to statistics prepared by the Ministry of Labour, changes in wage rates which came into operation in July in the United Kingdom resulted in an aggregate increase of approximately £384,000 in the weekly full-time wages of about 1,037,000 workpeople. The principal increases were to workers in the motor vehicle retail and repairing trade, workers in the general printing industry, operating and maintenance staffs employed by company-owned omnibus undertakings and workers in municipal tramway, trolleybus and omnibus undertakings. Wage increases were also made in July to engineering, supplies, motor transport and factory grades of the General Post Office. The Ministry says that, in the first seven months of this year, changes in wage rates led to an aggregate increase of £4,143,400 in the weekly full-time wages of 10,113,500 workpeople, compared with increases aggregating £5,920,000 for 11,615,000 workpeople in the corresponding period of 1956. At the end of July, the index of rates of wages (January 31, 1956=100) was 111 for all industries and services ; there has been no movement in the index since May. The index, incidentally, does not reflect changes in earnings brought about by such factors as alterations in working hours, or changes in the earnings of piece-workers and other payment-by-results workers due to changes in efficiency of operatives and machines.

The Ministry of Labour has also issued some preliminary findings resulting from its half-yearly survey of the average earnings of manual workers. In the last pay week of April, the average earnings of all manual workers were £10 4s. 7d., compared with £5 3s. 6d. in April, 1947. For men, the average earnings in the last week of April were £12 1s. 6d., and for women, £6 5s. 10d., the comparable figures for April, 1947, being £6 3s. 5d. and £3 7s. 4d., respectively.

Age Structure in the Engineering Industry

In the latest issue of *Occupational Psychology*, which is published by the National Institute of Industrial Psychology, there is included a study of age structure in the engineering industry. It has been prepared by members of a research unit at Bristol University. Their study dealt with men only, as the employment of women is influenced by a number of social factors which cannot be assessed. The information gathered by the research unit relates principally to light engineering. For the most part, those under the age of twenty-one have been disregarded, and the study is based on the assumption that the normal adult working life of a man extends from twenty-one to sixty-four years of age.

From the information which has been collected, the research team has reached the conclusion that men over the age of thirty-seven will give longer service than those who are younger, and that fewer of them will want to leave their employment voluntarily. The best age for engagement seems to be between thirty-seven and forty-four, and the worst, from the point of view of retaining workers, appears to be between twenty-one and twenty-eight. The study goes on to show that men who find their jobs too much for them as they get older do not usually want to be transferred to easier jobs for the same employer, but prefer to leave the firm altogether. If men are moved to what they look upon as superior jobs, it tends to counteract any desire to resign, a factor, the report claims, which suggests that firms might adopt with some confidence a deliberate policy of internal transfer to superior work. The team says that its study reveals " the existence of a definite age structure in firms in the engineering industry in the south-west of England. The ranking of jobs by age, which was substantially similar in all the firms studied, seems to have been the same over the last eight years. The largest single determinant of age structure is the difficulty inherent in the job itself, and the isolation and identification of such difficulties might lead to such modification of jobs that people could continue in them beyond the age at which they now appear to leave them. If that is possible, the report concludes, a substantial contribution to productivity should result.

Iron Castings Production

The production of iron castings in Great Britain in the second quarter of this year was, at 944,500 tons, 2 per cent lower than in the first quarter, and 7¼ per cent below the quantity produced in the second quarter of 1956. But in three sections of industry, the output of castings was higher in the second quarter of this year than it was a year earlier. These were automobile (including tractors), building and domestic, and railway equipment. Commenting on the figures, the Joint Iron Council attributes the fall in the total output of castings to difficult trading conditions in the pressure pipe and in some general engineering sections of the industry. The number of people employed in the ironfounding industry at the end of June was 137,800, compared with 138,500 at the end of March.

Coal Output

Coal production in Great Britain is now recovering from the effects of the holiday season. The total output last week was 4,365,800 tons, of which 4,095,400 tons came from the deep mines and 270,400 tons from opencast sites. In the thirty-five weeks of this year, ended last Saturday, production totalled 150,128,500 tons, compared with 146,738,500 tons in the corresponding period of last year. The improvement in deep-mined coal production has been maintained and is now about 2,500,000 tons higher than it was a year ago ; opencast output is about 1,000,000 tons better.

Coal consumption so far this year has been lower. In the thirty-four weeks ended August 24, inland consumption totalled 137,929,000 tons, and export and bunker requirements took up 5,538,000 tons (1,000,000 tons below the comparable figure for last year). Coal imports this year, at 2,239,600 tons, are about 2,000,000 tons below the figure recorded at the end of August, 1956.

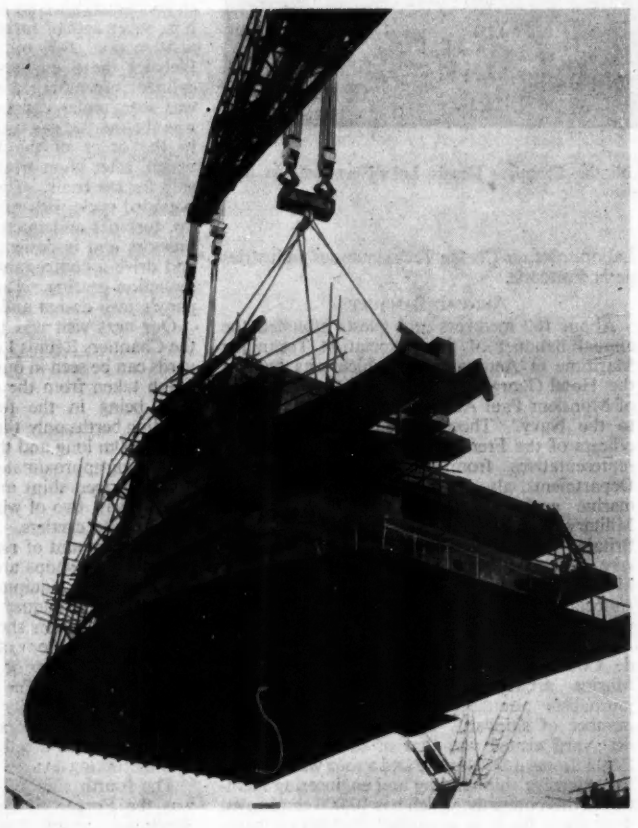
Association Technique Maritime et Aeronautique

THE fifty-sixth meeting of the Association Technique Maritime et Aeronautique was held in the Maison de la Chemie, 28 bis, Rue Saint-Dominique, Paris, from June 3 to June 7. The session opened with the general meeting on the afternoon of Monday, June 3, when reports were presented and the president surveyed progress during 1956.

The first paper read was "Use of Plastic Replicas for the Morphological Analysis of Fractures," by H. de Leiris, and it described a simple process for preparing plastic replicas of fractures. According to the paper, this process facilitates the morphological analysis of fractures by allowing a record of their precise aspect to be kept, even should repair operations involve destruction, and enables lighter and less cumbersome replicas of parts to be sent to the laboratory instead of the parts themselves. M. Roy and P. Duban presented a paper entitled "A Calculation Method for Great Deviation but Low-Pressure Ratio Blades," which gave a method of numerical integration for the equations of the three dimensional compressible flow in turbo machines. To demonstrate the use of the method an application to the design of cascade blades producing a large deflection, but a low-pressure ratio, was described. The authors said that a blade, so calculated, was tested at low Mach numbers and then at greater Mach numbers in the transonic range and the results were in general agreement with theory. In the next paper, "Non-Destructive Method of Macrographic and Micrographic Examination of Metal Parts," P. A. Jacquet and A. van Effenterre stated that a coating of nitrocellulose varnish formed a transparent replica which accurately reproduced the topography of a metallic surface. The use of such a replica eliminated the need for direct microscopic inspection and the cutting out of specimens, while aided by new methods of electrolytic polishing the replica system permits non-destructive metallographic examination.

On Tuesday morning the opening paper was "A New Application of O-Rings in the Erection of Sliding Distributors, Stop and Safety Valves," by J. Habersetzer. This was followed by "Electrical Protection of A.C. Auxiliary Networks on Board Ship," in which the author, L. Gatesoupe, described a convenient means of reducing the value of short-circuit currents in ship auxiliary networks, dealing more particularly with the internal characteristics of generators. A. Massenet read the next paper, which was "Results of Short-Circuit Tests on Rotating Machines and Switchboards Designed for Shipboard Installation" and which showed that the tests gave accurate values of the impedances and time constants used in the calculations of defect currents in a ship's mains. In his paper "Reflection on a Switch Apparatus Combined with H.R.C. Fuses," G. Bouvier covered a general study of the requirements to be met by the combinations of circuit breakers or relay-controlled contactors with high-rupturing-capacity fuses. He emphasised the advantage of such a combination and advocated a full study of any scheme where switch apparatus co-operates with H.R.C. fuses.

The meeting was continued in the afternoon with the reading of "Economics of Modern Hatch Covers," by P. L. Bain and R. Nagel, in which figures were given comparing a ship fitted with a watertight steel quick-handling flush 'tween deck hatch installation with a ship equipped with ordinary covers. J. P. Ricard, in his paper "Service Experience of High-Pressure, High-Superheat Boilers of Four Types," reported upon the troubles experienced and the lessons to be learned from seagoing experience in two liners on the Mediterranean-North Africa service and two liners on Transatlantic service. In the next paper, entitled "A Formula for the Calculation of the Angle of List Taken by a Prismatic Vessel with Negative Initial Metacentric Height," G. Solda thought that it might be advisable to modify the rule of the 1948 International Convention regarding negative stability. "The Liberty Ship 'William Patterson' with Gas-Turbine Machinery" was the title of a paper read by G. Hoffmann, who commented that the outstanding point with regard to the gas turbine is that it has a reversing stage included in the design. The final paper of the afternoon was "Atomic Energy for Merchant Ships," by G. Cahen and J. P. Ricard, in which the authors generally discussed various designs of reactors and pointed out the requirements and conditions to be met in the design of marine reactors.



Prefabricated deckhouse and bridge being handled by the heavy lift crane at the Chantiers de l'Atlantique

The first of four papers read on Wednesday morning, June 5, was "The Modane-Avrieux Testing Centre," by M. Pierre, which referred to the tests carried out by the French National Office of Aeronautical Research and gave particulars of wind tunnels under construction. These include a Mach 3 supersonic tunnel and three more having working sections for Mach numbers ranging from 3 to 8. H. Werle, in his paper "The Water Tunnel and its Use in the Study of Aerodynamics," outlined the scope and the principle of the O.N.E.R.A. water tunnel and described the testing methods. Examples were given to demonstrate how well the tunnel fits in with the numerous facilities used in aeronautical research. "Aircraft Control by Means of Jet Deflections" was the title of the paper read by G. Ernst, who referred to dissymmetrical jet deflection as an efficient means of producing the necessary stabilisation and control moments. Artificial stabilisation of the vertical take-off and landing of aircraft called for the use of short-time-response feed-back controls. P. de Valroger presented his paper "A New Engine, the Turbo-barillet," in which he suggested the simplification of the design of the gas-turbine-propeller unit and proposed the adoption of a cluster of barrel-mounted turbojets.

In the afternoon the first paper was "A New Method of Approximate Development of a Skew Surface," by R. Brisson, J. Le Rest and J. Boennec. The method, as applied to a strake of plating, was said to consist of using the development of an intermediate surface, generated by the chords of frames, from which the development of the strake could be derived. A saving of up to 90 per cent of time was claimed. The next paper, the "Use of Thomas Steel in Shipbuilding," by M. Allard, M. Borione, and M. Benichou, described the stages in the development of the Thomas process and its position with regard to the Classification Societies. J. Koziowski, A. Robakiewicz and E. Zabiello jointly presented the paper, "The Evolution of Construction Methods for Smaller Ships," which described a block method of construction, the use of which enabled thirty-two ships to be built in one year on one slip instead of twelve ships. The next paper was "Flame Cutting Machine with Electronic-Eye-Tracer Used in the French Naval Shipyard at Brest," by R. Thiennot and R. Brisson, and was followed by "'Osijek' Type Passenger Coasters—Sea Trials and Analysis of Voyage Data," by S. Silovic and M. Fancev. The paper gave the particulars of the passenger coasters and of the instruments used for taking the measurements. The trial results were compared with the model test predictions and a generalised diagram giving fuel consumption developed, and upon the basis of which an analysis was made of the engine-room log book.

The meeting was continued on Thursday morning, June 6, with the presentation by G. Salet and J. Barthelemy of a paper entitled "Practical Method for Computing in Three Dimensional Pipelines the Forces Due to Internal Pressure and Thermal Expansion," which described the method and showed that the computation, although apparently complex, was actually simplified due to the isotropy of the flexibility. Two quick approximate methods were also given. R. Legendre, in his paper "Turbine Blade Profiles," gave a practical method for use in calculating subsonic turbine blade profiles. The third paper of the session was "Visualisation of Incompressible Flow in a Single Duct of Centrifugal Compressor," by E. Maillet and J. Le Mahach, and was followed by "Oil Film Elasticity and Damping Forces and Their Influence upon Critical Speed Transition," by R. Lemaitre. The author reviewed the development of the oil film theory and gave the elasticity and damping coefficient formulæ for a semi-circular bearing according to Stieber's hypothesis.

In the afternoon the first paper presented was "Pulse Excitation as a Method of Structure Analysis," by G. Coupry, which stated that pulse methods were little used because of the difficulties arising in the analysis of the transient conditions obtained. A method based on pulse excitation by rockets was explained. The next paper was presented by J. Etienne and G. Chanty and entitled "Non-Destructive Testing of Butt-Welded Joints by Ultrasonics." The authors reviewed both the principle and the equipment used for ultrasonic impulse sounding and as a practical application gave data relating to the butt welds of ships' deck plating obtained by this

Aerial view of the Ateliers et Chantiers de Bretagne with the Chantiers Reunis Loire-Normandie in the foreground

method. H. de Leiris and H. Dutilleul were the authors of the paper "Contribution to the Experimental Stress Analysis of the Stiffeners in a Bulkhead Under Uniform or Hydrostatic Pressure," which attempted to analyse from laboratory experimental records the observations made on bulkhead stiffeners under fluid pressure. The points considered were: how the law of stress variation is influenced by the pressure; how actual stress compares with theoretical values computed for a beam of constant section and subjected to uniform transverse pressure; and the influence of gusset plate design on actual stresses. The fourth paper of the afternoon was "View on the Fatigue Strength of Joints Used in Shipbuilding," by H. de Leiris, and the final paper was by M. Jourdain and entitled "Comparative Tests Between a Corrugated Bulkhead and a Stiffened Plane Bulkhead Under Fluid Pressure." The paper gave the results of applying uniform hydraulic pressure to a plane bulkhead with stiffeners and a vertically corrugated bulkhead, both constructed to Classification Society rules. Stresses were measured at low pressure with the structure in the elastic range and then the pressure was raised until major damage resulted. The resistance of both bulkheads was found to be the same and the effectiveness of the stringer web across the corrugations was established, while there was fair correlation of stress measurements in the elastic range with those calculated by Professor Jaeger's method.

On Friday morning, June 7, the meeting opened with the presentation of "Direction Finding Aboard Merchant and Fishing Vessels," by J. Bes, and was followed by a paper by F. Bouteiller, entitled "Use of Radar in Navigation at Sea," which considered how radar could be modified to aid the navigator in conditions of poor visibility. In the next paper, "Device for Prevention of Collision at Sea," P. Gandillére described a device for automatic transmission in U.H.F. to obtain apparent direction of oncoming ship and the actual course and speed of oncoming ship; automatic plotting; and automatic watch on an oncoming ship and alarm signal. Paper number four by R. Pelicant was "Harbour Control Radar," and described the working of the radar station at the port of Le Havre. The final paper read at the technical meetings was "Radar Data Transmission," by G. Cauvin, and described different systems of P.P.I. picture transmission by radio links. Examples were given illustrative of the various techniques.

On Friday afternoon the delegates visited the Laboratoire du Centre Technique des Industries de la Fonderie.

Annual Banquet

About 160 members and guests attended the annual banquet of the Association Technique Maritime et Aeronautique, which was held at the Hotel George V, Paris, under the presidency of Monsieur Paul Anxionnaz, Secretary of State to the Navy. Those present included senior officers of the French Navy and Air Force and representatives from associated Government Departments, also shipowners, shipbuilders and marine engineers, together with the Naval, Military and Air Attachés of Canada, Great Britain, Holland, Indonesia, Israel, Italy, Norway, Poland, Portugal, Russia and Yugoslavia. Monsieur Georges Bourgès, the president of the Association, welcomed the company and they were also addressed by Monsieur Paul Anxionnaz.

As in previous years, the Chambre Syndicale de Constructeurs de Navires et de Machines Marine arranged for the British technical journalists attending the meeting to visit a number of shipyards and engine works. The first yard visited was that of the Chantiers de l'Atlantique at St. Nazaire and a tour was made of the extensive shipbuilding and engineering facilities of this company, which has 10,000 employees. The order book is extensive, numbering some twenty-five ships, mainly oil tankers, ranging in size from 27,000 tons deadweight to 73,000 tons deadweight, three of which have been ordered by the Société Maritime Shell, Paris. At the time of the visit the oil tanker "Tidewater," of 51,850 tons deadweight and a full load displacement of 67,100 tons, and propelled by a set of double reduction geared turbines of 19,000 s.h.p., had just completed trials. Perhaps the most interesting section of the yard is the Forme d'Ecluse, which consists of a dry dock associated with a building platform, where four ships, in pairs, can be built. The aircraft carrier "Foch" occupies one of the berths at present. A portable wooden wall divides the dock from the building area so that the dock can be flooded as required without stopping the progress of the ships under construction. Within one of the dock walls is a *bassin d'essais des carenes*, but although built as such, it is not used as a ship model tank. All operations are well served by cranes, which include one of 45-ton capacity at 35m, three of 6/8-ton capacity on one wall, and others elsewhere. On a centre track is a large travelling crane, which serves the berths and the dock, and which can lift 250 tons at 43m radius and 120 tons at 66m radius and, in addition, is equipped with a 60-ton travelling hook. Our illustration shows the crane handling a prefabricated bridge and deckhouse, weighing 200 tons, from the prefabrication area to the main hull. Among the other items of interest noted during the rapid tour was the wet sand blasting of ship plates to remove scale, the movable sectional roof of the prefabricated shop to allow for the easy removal of units, and a Pielstick diesel engine of 5000 h.p. under construction.

From the mouth of the Loire the party journeyed inland to Nantes and the next day paid a visit to the Ateliers et Chantiers de Bretagne. There are three building berths and the order book shows that orders for about twenty cargo ships of up to 13,500 tons deadweight have been placed with the company. Plans are in hand to increase the maximum length of ship which can be built; to overcome restrictions imposed by lack of space a multi-storey office building is to be built, and also a new prefabrication shop having a specially strengthened roof to provide storage space for prefabricated work. It will be remembered that this yard uses plates of a standard size for building purposes. In the well-equipped engine shops, which have an annual capacity of 300,000 h.p., seven sets of turbine machinery were under construction for oil tankers. M.A.N. and Pielstick diesel engines are built, and an eight-cylinder supercharged engine of the latter design was seen under construction. Also of interest was the marine gas turbine which has been built to the order of the French Government and which, after shop trials, is to be installed in a ship for sea trials. The unit has a straight compounded cycle with reheat between the h.p. and l.p. turbines and intercooling between the compressors and is designed to develop 3500 s.h.p. and drive a controllable pitch propeller through reduction gearing. The propeller is of the company's own design and manufacture.

Our next visit was to the neighbouring yard, the Chantiers Réunis Loire-Normandie, and both yards can be seen in our reproduction of a photograph taken from the air, the Loire-Normandie yard being in the foreground. Of the four building berths only three are in use, the longest being 160m long and the largest ship that can be built being approximately 13,000 tons deadweight. Some thirteen ships are on order, including six for Norway, two of which are on the stocks, and two bauxite carriers. As in most yards a considerable amount of reconstruction is in hand or planned; old shops are being demolished, while in others new equipment is being installed to modernise techniques and improve efficiency. The prefabrication shop has a sectional rolling roof so that the floor of the shop can be plumbed by external cranes for the easy removal of prefabricated work. The shipyard cranes are being increased in capacity and the company also possesses a floating crane capable of a lift of 100 tons. There are excellent machine shops capable of undertaking a variety of work.

The fourth shipbuilding establishment visited was the Forges et Chantiers de la Gironde at Bordeaux, which has been in existence since 1882. Planning to employ modern building techniques has resulted in only three of the four berths being used, and a scheme to extend the maximum effective length, which is at present 182m. Crane facilities at the berths include a 40-ton portal crane, a 50-ton tower crane, and several smaller units, while the 200m dry dock is served by a 140-ton portal crane. At the fitting-out quay, which at present is being extended and reconstructed, is a crane of 250 tons capacity at 25m radius, 125 tons at 38m radius, and 40 tons at 40m radius. One of the disadvantages under which the yard suffers is its bisection by the railway, so that heavy items have to be transferred over the railway from one section of the yard to the other by means of a 250-ton transporter. Another handicap, but not serious in character, is the need to maintain a roadway linking the Quai de Brazza across the river end of the slips, which involves the removal by crane of the appropriate section of road to permit a ship to be launched. Personnel employed in the yard number about 1700, production capacity is approximately 60,000 tons per annum, and present orders amount to about twelve ships, including cargo boats, oil tankers, and two ore carriers of 30,000 tons deadweight.

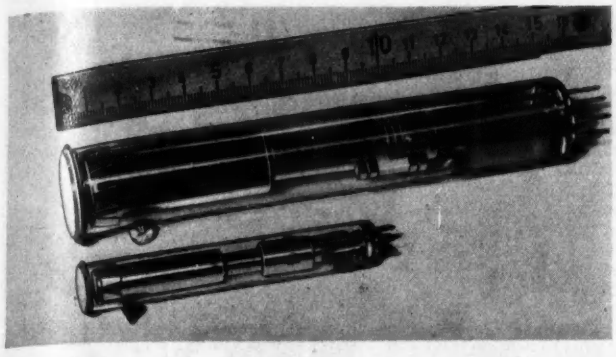


Fig. 1 (Left)—Normal and miniature versions of "Resistron" camera tube. Fig. 2 (Right)—Bore-hole inspection camera. In the centre is the housing, with cable inlet on the right. The camera may be seen at bottom right, while bottom left shows the inspection mirror with surrounding lights and the driving motor, which makes possible a 360 deg. field of observation

Industrial Television Equipment

Industrial television, which has come much to the fore in recent years, finds an application in situations where the direct observation of an industrial process is difficult or impossible, or where it is desired to watch several distant localities from a single control position.

In the equipment made by Grundig-Werke, Fürth/Bayern, German Federal Republic, transmission takes place over cables up to a maximum distance of 1700m. Wireless transmission is also possible, although additional equipment is required, as well as a licence to operate the transmitter. Lens opening, focus and direction can all be remotely controlled.

The Grundig "Fernauge" television camera makes use of a "Resistron" image recording tube (Fig. 1). This is similar to the American "Vidicon" tube, and has a sensitive layer of antimony trisulphide. Pictures are transmitted at the rate of fifty per second and with a lens opening of 1 : 2 the lighting of the object must be at least 200 lux, in order to give the necessary intensity of 4 lux at the tube.

The usefulness of the equipment depends largely on how adaptable it is to special requirements. Watertight and dustproof housings, as well as specially cooled cameras, are available.

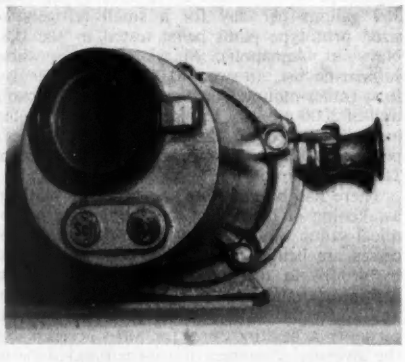


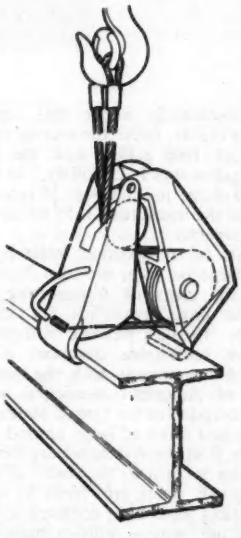
Fig. 3—Firedamp and explosion-proof housing for "Fernauge" television camera. The window is of plastic material

In Fig. 3 we show an explosion proof housing for use in mines, &c., which has recently come on the market. The window is made from "Flexiglass" plastic; on the right is the connection for the cable.

Development of a miniature recording tube (Fig. 1) enabled Grundig to produce a television camera which can be used for inspecting the interior of pipes of only 60mm internal diameter. Another application is the special camera shown in Fig. 2, which is for observing the walls of bore-holes.

Safety Lifting Claw for I-Sections

Attaching an I-beam to a crane hook is ordinarily a difficult job to carry out in a safe manner. A self-releasing claw which grips tightly under load has been introduced by Gebr. Dickertmann Hebezeugfabrik A.G., Jöllenbecker Strasse 13, Bielefeld, German Federal Republic. The two jaws of the claw grip the sides of the flange, the gripping pressure being derived from the tension in the lifting rope which is attached at one end to one jaw and at the other to the crane hook. The jaws are hinged together at the upper end and the rope is taken over two pulleys, one in each jaw, in such a way that its direction is changed from

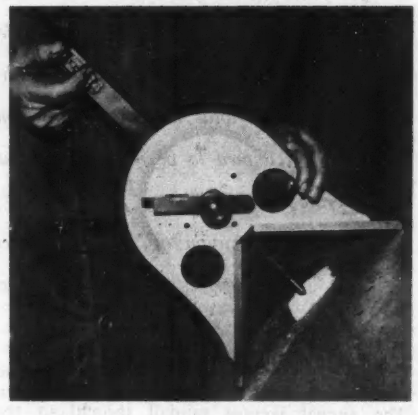


Safe lifting claw for I-section R.S.J.

vertical to horizontal. Under the action of the load the jaws are pulled together, but when the beam is set down the tension eases. A spring ensures that the jaws are not released until the hook has descended a further 400mm. Since the rear jaw is heavier, the claw always, on detaching itself, falls away to the rear so that the workman who is standing in front is not endangered. Release of the claw by hand, which is always a dangerous procedure in erection work, is altogether avoided.

Marking-Out Punch for Pipework

A special marking-out punch for use on the external and internal surfaces of pipes has been put on the market by Albert Ott, Gudulastrasse 5, Essen, German Federal Republic. As its name implies, the Model "ORKA 1" radial punch always maintains its radial direction, at right angles to the pipe surface, by virtue of the vee-shaped base seen in the accompanying illustration. In setting up the instrument for use on a pipe of given diameter, the height of the punch is adjustable so that when the vee-base is set against the workpiece, the marking point is at a small distance from the metal or touches it lightly. The correct position on the circumference is determined by means of a spirit level and scale,



Marking-out punch set up for 45 deg. position

the latter being graduated from 0 deg. to 180 deg. in both directions, the positioning being done by setting the level to the required angle. The punch is spring-actuated on the principle of a firing-pin. For scribing, a bracket with crosslines is available which can be attached to the punch.

Fewer Dutch Steam Locomotives

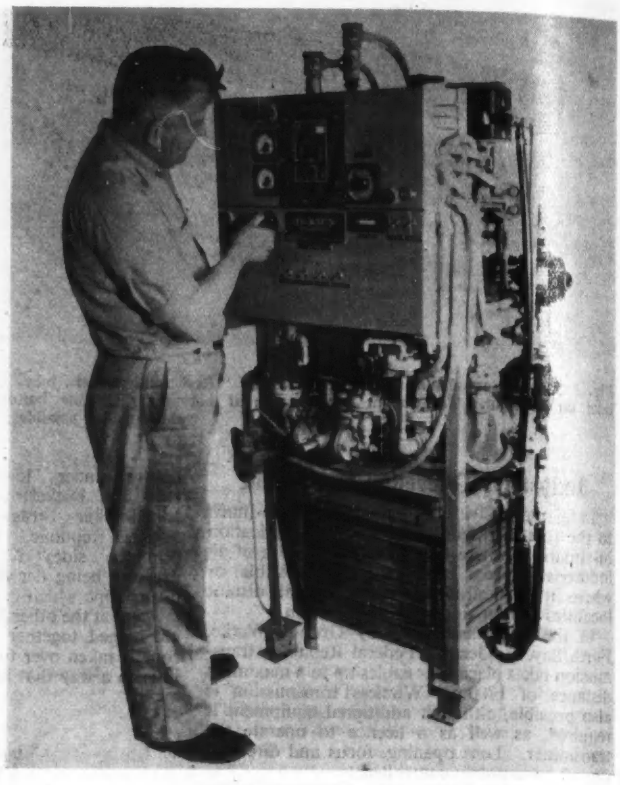
Whereas in 1951 the Netherlands Railways still handled 28 per cent of their total traffic with steam locomotives, while 65 per cent was electric and 7 per cent diesel, these figures now have changed to 6, 69, and 25 per cent respectively. One of the results of this reduction in steam traction at the expense of electric and diesel power has been a saving of coal. Although the total traffic increased by 8 per cent, the consumption of energy (in terms of calorie equivalent) was lower by 11 per cent. In 1958, there will be 607 diesel locomotives, of which 280 will be main line engines, and 278 shunting locomotives; all steam engines will then have been withdrawn.

International Congress for the Promotion of Labour and Workers

At the closing session of the International Congress for the Promotion of Labour and Workers, which was held last month at Jambes (Namur), a resolution was passed expressing the hope that the congress would be repeated every three years, in Belgium or elsewhere; in the meantime, study sessions should be organised annually on a national level as a kind of preparation for the international congress, to cover topics of labour sociology, security and labour services. It was suggested that an International Centre should be set up at Namur with the object of studying labour problems and co-ordinating their solution, preparing international and national congresses, and handling documentation and information services.

Production of Fresh Water by Ion Exchange Membrane Demineralisation

BY OUR AMERICAN EDITOR



Ion exchange membrane units have found growing application recently in the demineralisation of saline waters for drinking, household and industrial use. The apparatus developed by Ionics, Incorporated, is designed to be effective in the demineralisation of brackish waters of 1000 *to* 6000 *p.p.m. total dissolved solids content, and, in this field, is claimed to be more economical to install and to operate than distillation plants. The article reviews the general application of water demineralisation processes and describes the electric membrane process.*

THE world problem of meeting the demand for fresh water is mainly one of distribution. The annual average rainfall throughout the world is approximately twenty times the present average demand for all uses. The problem is associated with the fact that the rainfall is far from evenly distributed; in addition a large fraction evaporates before it can be utilised. Much of the remainder passes into saline sources such as the ocean and underground pools. If it were not for multiple-series use, conditions in many areas might be considerably more serious. Those areas whose natural water supplies are adequate in quantity but are contaminated with dissolved solids are considerably better off than the completely arid areas, but a major development of the area will only result if a process for desalting the water at a cost consistent with the economy of the area is available.

Many processes are available to-day for accomplishing the conversion of saline to fresh water, and the problem is basically one of the simplest of chemical separation. The major consideration is that the cost of making the separation must be low. The processing of 1000 gallons of sea water to remove 290 lb of salt or 1000 gallons of a brackish water to remove 29 lb of salt must be accomplished at a total cost of approximately 30 cents if the process is to compare favourably with the average household cost in the United States. Thus, in examining any process associated with water treating, the major emphasis must be placed on the economics of the process. The cost of distilling water is high. The published cost estimates for the most recent large water distillation plants including the unit at Morro Bay in California, which was described in THE ENGINEER of August 31, 1956, range from 1·75 dollars to 2·80 dollars per 1000 gallons. These estimates are for plants having capacities up to 2,700,000 gallons per day. Furthermore, the required investment or first cost is high, ranging from 2·80 to 3·70 dollars per daily gallon of capacity. By contrast, in its quintennial study of U.S. municipal water systems, the American Water Works Association found that in 1950 the mean price paid by consumers for delivered municipal water was 20 cents per 1000 gallons, and the mean book value of municipal water systems was approximately 50 cents per daily gallon of capacity. These figures include distribution costs as well as production and treatment costs. On the other hand, several of the large western cities of the United States had cost indices substantially above this figure. For instance, at Dallas, Texas, the average revenue was 42 cents per 1000 gallons and the investment per daily gallon was 1·25 dollars. In Oklahoma City, the average revenue was 35 cents per 1000 gallons and the investment 1·55 dollars per daily gallon of capacity.

The costs of transporting water by truck or railway, barge or ship, are also high, but fortunately, the costs of transporting water by pipeline in large quantities are much more reasonable. Because pipeline transportation of water over reasonable distances is relatively cheap, and corresponds with the present price structure of American municipal water, and because most parts of the United States are within a few hundred miles of large unused sources of fresh water, it has been unnecessary for American communities to turn to the costly alternative of converting salt water into fresh by distillation. Such practices have been confined to shipboard and island use, remote military bases where the water usage is generally small, remote work camps, particularly for companies in the extractive industries where minerals are found in arid areas, and to a few growing communities in the Caribbean and the Middle East. The three largest sea water distillation plants to-day are at Curaçao in the Dutch Antilles, at Kuwait on the Persian Gulf and on Aruba in the Caribbean.

Process Costs

With the development of the electric membrane process by Ionics, Incorporated, of Cambridge, Massachusetts, a substantial cost reduction has been achieved in saline water conversion. The electric membrane process, operating on saline waters having salinities up to approximately 6000 p.p.m. of total dissolved solids, can now produce potable water in quantities up to several million gallons per day, at total costs of less than 1 dollar per 1000 gallons and at investment costs of less than 1·20 dollars per daily gallon. The exact costs vary with the salinity of the water to be treated, the size of plant and other factors. These conclusions are based on some eight years of research and development, three years of field operating experience, and over 40,000 hours of logged operating time on twelve electric membrane units. These units have operated on natural saline waters varying in salinity from 1500 p.p.m., which is just over the maximum U.S. Public Health Service limit for drinking water, to 35,000 p.p.m., which is the salinity of the Atlantic Ocean off the coast of Maryland. The saline waters treated had a variety of chemical compositions, including waters containing besides their normal salt components up to 1000 p.p.m. of alkalinity, 50 p.p.m. of hydrogen sulphide, 3000 p.p.m. of hardness, 10 p.p.m. of iron oxide, and the rich plankton growths of the fishing banks off Massachusetts. The temperatures of waters treated have varied from 120 deg. Fah. in the deserts of the Middle East down to 32 deg. Fah. or less in the Atlantic Ocean in the winter. The capacities of individual units have varied from 360 gallons per day for a small refrigerator-sized prototype plant being tested by the U.S. Navy at Annapolis, Maryland, for possible submarine use, to over 40,000 gallons per day for a trailer-mounted unit operated on a brackish well of 2000 p.p.m. The largest unit built so far has an output of 86,400 gallons per day of fresh potable water from a brackish well source of 3100 p.p.m. impurity.

There has been during the past few years an awakening of interest in the problem of economical saline water conversion. Many new processes are being suggested or actually explored by groups in the United States, most of the European countries, the Union of South Africa, and Australia. The interest in this problem is certainly a healthy thing for all concerned, but the diversity of sources of information has inevitably led to some misunderstanding. One of the clearest recent evaluations of saline water progress was undertaken by the U.S. Assistant Secretary of the Interior, Mr. Fred G. Aandahl, speaking to the Diamond Jubilee Conference of the American Water Works Association. He first cautioned that cost estimations for various saline water conversion processes have not necessarily been on a comparable basis in the past. With this qualification in mind, however, he went on to place the cost of fresh water from vapour compression, multiple-effect distillation, or solar distillation processes as now available for practical use somewhere in the range of 400 to 1200 dollars per acre-foot or 1·22 to 3·67 dollars per 1000 gallons. The Secretary went on to predict that the application of improvements now being designed and developed under the Department of Interior's programme, "may be able to produce" or "gave promise of producing" water by these processes at costs as low as 200 dollars per acre-foot or 62 cents per 1000 gallons, and perhaps, with further research in

some cases, as low as 100 dollars per acre-foot, or 31 cents per 1000 gallons.

These figures underline the magnitude of the cost "breakthrough" which has already been achieved by the electric membrane process. For waters up to 5000 p.p.m., the electric membrane process is already in the cost range of 31 cents to 1.00 dollar per 1000 gallons. The electric membrane process is expected to approach costs well below 100 dollars per acre-foot in the future. Technical objections can, of course, be raised to the comparison of the costs of the electric membrane process on brackish waters with the costs of other processes which apply to sea water or brackish waters. It is true that the electric membrane process has costs which depend on salt content, whereas most distillation processes have costs which are essentially independent of salt content. However, from the point of view of the economics of the water user, the comparison is quite practically meaningful. One would assume that a user of fresh water is not concerned with the original source of his water but is mostly concerned with how much he has to pay for the water. The present-day costs of the electric membrane process for brackish waters are already as low as the probable future costs for any waters by distillation. Therefore, the water user who needs to convert saline water can do as well to-day using the electric membrane process as he will be able to do perhaps five or ten years from now using distillation, if he is able to-day to find brackish water in the 1000 to 5000 p.p.m. range to treat. It should be noted here that brackish water of 1000 to 5000 p.p.m. total dissolved solids content is readily available in the Western United States, the Middle East, South and North Africa, and parts of Australia. Hence, this restriction on the most economical range of the electric membrane process does not rule out many practical cases.

Some authorities have tended to associate the use of distillation processes on sea water with seaside locations and the use of brackish water with inland locations. This limitation on the use of brackish water to inland locations is not justified by economics in the many cases where seaside locations have brackish water of lower salinity. In many seaside locations, including Kuwait, the Florida coast, the Lower Rio Grande Valley of Texas, most of the Caribbean Islands, the area surrounding the Persian Gulf in the Middle East, the Mediterranean and Red Sea coasts of North Africa, and the South Atlantic coast of the Union of South Africa, brackish waters of 1000 to 5000 p.p.m. are available within a few miles of the sea coast in adequate quantities for part or all of the area demand. Such brackish water has several attractive characteristics as compared with sea water, besides its lower salt content : (1) While sea water is available only at the sea coast, brackish waters are widely distributed not only near the sea coast but inland as well, thus cutting down pipeline costs. (2) While sea water is available only at sea level and must be pumped to the land elevation where it will be used, underground brackish waters usually occur at an elevation higher than sea level and sometimes even under artesian pressure. (3) While most underground brackish waters emerge clear and sterile, sea water is subject to pollution by human and industrial wastes and, in wartime, to purposeful contamination with radiological and biological agents by enemy action. Furthermore, even when unpolluted, most sea water contains relatively rich growths of plankton and animal life and is highly corrosive to handle. For all of these reasons, it would seem that sea water is perhaps the least attractive alternative in the overall economics of supplying land areas with fresh water. The economic advantages of the electric membrane process would certainly merit prior or parallel consideration if the objective is to reduce to the utmost the cost of fresh water which must be delivered to consumers.

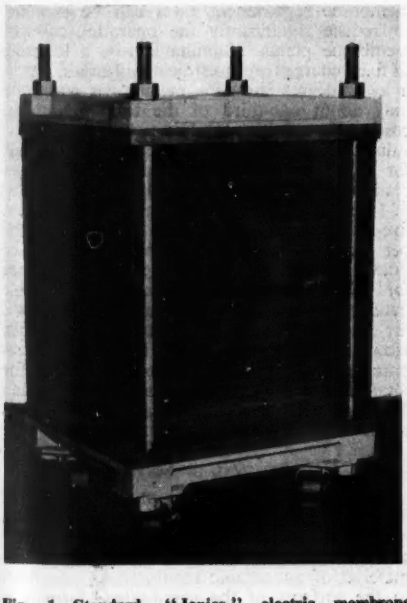


Fig. 1—Standard "Ionics" electric membrane stack containing 300 membranes and 300 spacers

The Electric Membrane Process

The operation of the electric membrane process is dependent upon the use of two barriers known as cation and anion membranes, having selective permeability. The cation membrane is an electrically conductive plastic sheet which permits the passage of only positively charged ions, such as sodium ions, under the influence of a d.c. potential. The blocking or repulsion of anions is the result of the fixed negative groups evenly distributed within the insoluble matrix of the cation membrane. The anion membrane is similarly constructed but is selective for anions. A multi-cell system is shown in Fig. 2,

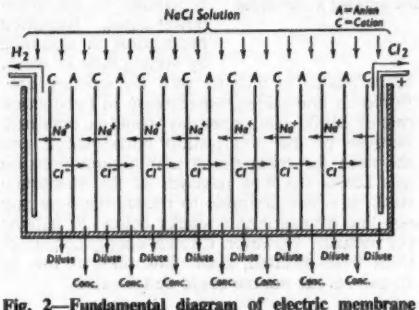


Fig. 2—Fundamental diagram of electric membrane water demineralising process

each cell being composed of an anion membrane and a cation membrane suitably separated from each other by spacers to permit the passage of the saline water. The membranes are arranged alternately with regard to sign and the cells are electrically in series between a single set of electrodes. With the impressing of a d.c. voltage across the terminal electrodes, the resulting migration of the ionic constituents results in an increase in salt concentration in one-half the flow passages and a decrease in the others. This basic multi-cell system can be utilised to separate a multitude of highly ionised constituents from non-ionised or slightly ionised constituents. In the case demonstrated, the ionised constituent is sodium chloride and water is the slightly ionised constituent.

Since the selectivity of the membranes can be shown to be high, particularly in the brackish water range, the demineralisation capacity of the system can be determined using Faraday's law and remembering that each equivalent of current transfers an equivalent amount of ions through each membrane. The d.c. energy input into the system follows Ohms laws, i.e. the power input is proportional to I^2R, where I is the d.c. current and R is the resistance of the series arrangement of the cells. A negligible fraction of the energy is associated with the theoretical separation of the salt and water. For a fixed change in the concentration of the diluting stream in passing through the unit, the resistance of the system is approximately constant. The rate of water production or throughput under these conditions is proportional to the current or d.c. voltage, while the power is proportional to the square of the current. Thus, the throughput of the unit is proportional to the square root of the d.c. power input and the d.c. energy per 1000 gallons produced is proportional to the throughput. In this manner the d.c. energy consumption per 1000 gallons of water produced for a fixed change in concentration of the diluting stream can be changed over a wide range with a correspondingly radical change in production rate. For example, a membrane system processing sea water on the shore at Cape Cod has been operated at a d.c. energy consumption of 10kWh and 100kWh per 1000 gallons on the same day.

For any condition of concentrations and flow rate there is a maximum d.c. voltage or power input that can be tolerated, giving maximum unit production. This limit is the result of a film concentration gradient being established at the boundary of the membranes. Any further increase in d.c. power input would result in decomposition of water, reduced efficiency and only slight increase in throughput. The higher the velocity of the diluting stream, the greater the permissible power input. Thus, it is not desirable to vary greatly the flow rate of the diluting stream in the operation of a membrane unit.

Neglecting any electrode over-voltage losses, the resistance of the series of membrane cells shown in Fig. 2 is the sum of the individual resistances of the membranes plus the equal number of flow passages. As an approximation, the resistance of each of the flow passages is proportional to the average concentration of salt solution within the flow passage. The resistances of the membranes, however, are approximately constant, except for Donnan diffusion experienced at the higher concentrations. Thus, for a fixed d.c. voltage across the system, at the lower concentrations the system tends to maintain a constant ratio of influent to effluent concentrations of the diluting stream and, at high concentrations, the system tends to maintain a constant difference between influent and effluent concentrations. The following equation describes the foregoing energy, throughput and membrane area correlations ; since certain assumptions are inherent in its derivation, it should be treated only as an approximate relation. The safe limits of d.c. power input and concentrations are indicated also :

$$(N_i - N_o)\log_{10}\frac{N_i}{N_o} + 10^{-4}(N_i - N_o)^2 = \frac{6AU}{F} \text{ (at 70 deg. Fah.),}$$

where :

N_i = total dissolved solids in feed-water, p.p.m.
N_o = total dissolved solids in product water, p.p.m.
A = plant membrane-pair area, ft²
U = d.c. energy per unit water produced, kWh per 1000 gallons.
F = production rate of product water, 1000 gallons per hour.

Note.—

$$\left(\frac{U}{N_i - N_o}\right)_{maximum} = 2{\cdot}5 \times 10^{-3}\text{kWh per 100 gallons per p.p.m.}$$

$$(N_i)_{maximum} = 6000 \text{ p.p.m.}$$

Plant Design

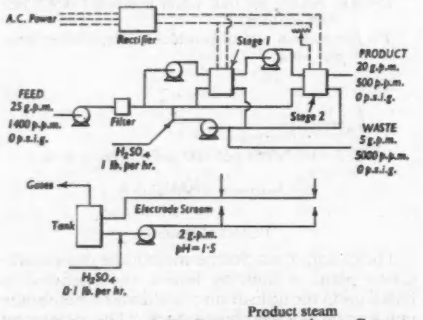
The design of an electric membrane demineralisation plant as built by Ionics, Incorporated, is based upon the utilisation of a standard membrane unit known as a membrane stack. The membrane stack is composed of approximately 300 membranes approximately 18in by 20in by 0·030in thick, and separated by the plastic spacers, of approximately the same dimensions, as shown in Fig. 3. The overall height of the stack is approximately 30in ; a single set of electrodes serves the stack. The available membrane-pair area for salt transfer is approximately 185 square feet per stack. The hydraulic capacity of both the diluting and concentrating streams through the 150 flow passages provided for each is approximately 20 gallons per minute ; a pressure loss of approximately 30 lb per square inch is required to provide this flow rate, corresponding to an average pumping power per stack of approximately 2kW. The method of utilising the membrane stacks with other auxiliary equipment for demineralising saline waters is illustrated in

Fig. 4. The typical case chosen for illustration is the production of 28,000 gallons per day of 500 p.p.m. product water from a 1400 p.p.m. brackish water. The total quantity of water required for the product stream (20 gallons per minute) and the blow-down from the waste or concentrating stream (5 gallons per minute) is subjected to some form of pre-treatment prior to entering the membrane stacks. The required

Fig. 3—Assembly of standard "Ionics" membrane stack showing a membrane about to be placed over a spacer

pre-treatment may range from simple sand filtration to aeration, settling, coagulation, chlorination and sand filtration, depending upon conditions.

The product or diluting stream is passed successively, by re-pumping, through the two membrane stacks in series flow. Approximately 40 per cent of the salt is removed in each stack. Thus, in two-stage operation, 64 per cent of the salt in the feed-water is removed. This corresponds to the maximum safe energy input to the membrane stacks and, for most applications, the maximum energy input in this range of concentrations is the optimum condition from a cost point of view. The d.c. voltage to the individual membrane stacks is adjusted by stepped-transformers and rheostats to achieve the



Stage No.	D.C. voltage	D.C. amps.	D.C., kW	Pumping,	Product steam concentrations, p.p.m. In	Out	Per cent. removed
1	220	7·8	17	2·0	1400	834	40
2	220	4·7	10	2·0	634	500	40
		12·5	27	4·0			

Fig. 4—Flow diagram of representative "Ionics" two-stage demineralising plant of 28,000 gallons per day capacity

proper demineralisation. The concentrating stream flows through each membrane stack at a rate of approximately 20 gallons per minute and parallel to the flow of the diluting stream within the stacks. Externally, the concentrate stream flows to the membrane stacks connected for parallel flow within a closed recirculating loop. This scheme permits the utilisation of a single concentrate pump and the conservation of waste water. The recirculating loop is blown down or continuously diluted by introducing raw feed-water into the loop. A blow-down rate of 25 per cent or less can be achieved in most cases. In the illustrated case, the total salt transferred is discharged as a concentrated stream of 5000 p.p.m.

A separate stream, called the electrode stream, serves the electrode compartments at the ends of the stacks. All electrode compartments are connected hydraulically in parallel and a recirculating system is employed. The electrode stream serves two major functions: the removal of dissolved and gaseous products resulting from the chemical reactions at the electrodes, and the prevention of basic precipitates forming in the cathode compartment and adjacent flow cells. The latter is accomplished by continuously feeding a small amount of acid into the recirculating loop. For many waters, it has been found necessary to feed a small quantity of acid into the recirculating concentrate stream to prevent the deposition of calcium carbonate. By changing the number of stages or stacks in series waters of greater or less total dissolved solids can be readily handled at maximum power input. Increased production is obtained by adding lines of membrane stacks in parallel with the existing line. For each line added, an increase in production rate of 28,000 gallons per day would be obtained. Because of the polarisation phenomenon and the need for maintaining a minimum pressure loss across the flow passages of the membrane stack, it is not desirable to reduce the flow rate per line of membrane stacks below 20 gallons per minute. However, if lower energy consumptions were dictated, stack flow rates as low as 10 gallons per minute could be tolerated.

Economic Considerations

Due to the relationship between plant size, power consumption and throughput, it will always be possible to determine the optimum investment for any particular application. The major costs associated with 1000 gallons of product water can be classified into one of two groups: charges that decrease as plant size is decreased for a fixed throughput rate, and charges that increase as plant size is decreased for a fixed throughput rate. Fixed charges on investment, except rectification equipment, cost of replacement parts, and pumping power fall into the first group. Power costs and fixed charges on rectification equipment fall into the second group. The minimum total cost per 1000 gallons produced occurs, for brackish waters, at the point where the cost of d.c. power is approximately equal to the summation of charges of the first group. The fixed charges of this group at present-day prices range from 15 to 25 cents per 1000 gallons per stack.

Under these conditions, all plants for processing brackish water, because of power input limitations, must operate at considerably less power than the optimum would dictate. For example, the plant illustrated in Fig. 4 utilises two membrane stacks, which is equivalent to a fixed charge of 43 cents per 1000 gallons for plants in the range of 100,000 gallons per day. The energy consumption in the membrane stacks, assuming a 90 per cent rectifier efficiency, is approximately 3kWh per 1000 gallons. At a power cost of one cent per kilowatt-hour, the plant is far from the optimum power input. If it were possible, the optimum would dictate a plant approximately one-fourth the indicated size and the total cost per 1000 gallons would be approximately 25 cents instead of 46 cents per 1000 gallons.

The size of membrane plants and the total power consumption required as a function of the total dissolved solids in the feed and product waters are presented in Fig. 5 for the case of

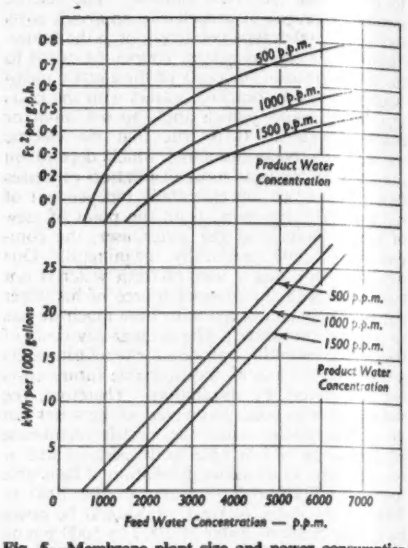


Fig. 5—Membrane plant size and power consumption as a function of total dissolved solids content of feed water

maximum power input to the membrane stacks. The correlation of power consumption of Fig. 5 corresponds to approximately 5kWh to 7kWh per 1000 gallons per 1000 p.p.m. of solids removed. The size of the membrane plant, as determined from Fig. 5, can be directly converted into the number of membrane stacks. Excluding the cost of the energy going to the rectifier and stacks, the approximate breakdown of operating cost per 1000 gallons of water is as follows:—

	Per cent	Cents per 100 gallons per stack
Membrane replacement	42 to 46	6·5 to 10·0
Investment amortisation	23 to 28	3·6 to 6·1
Operating and maintenance labour	9 to 13	2·0
Replacement parts	9 to 10	1·5 to 1·9
Pumping power	8 to 11	1·7
Acid	1 to 4	0·2 to 0·4

Membrane replacement is by far the greatest single cost factor. The replacement rate of one-third per year is a conservative estimate based upon the first year of operation of several plants, including the experimental plants. Lower membrane manufacturing costs and lower membrane replacement rates can be expected to reduce significantly the operating costs of membrane plants. Simultaneously, a lowering of fixed charges on investment will result, but to a lesser degree since the membranes constitute only about one-third of the total investment costs. The resulting total costs vary from a low value of approximately 20 cents per 1000 gallons for a 40 per cent single-stage operation in a plant of 1,400,000 gallons per day to a high value of 1·33 dollars per 1000 gallons for 92 per cent five-stage operation in a plant of 28,000 gallons per day. Some definite conclusions can be drawn from these present-day costs. Except for special crops of an extremely valuable nature, the use of the electric membrane process for agricultural purposes to-day is not feasible. However, for household uses, the electric membrane process can demineralise saline waters for total costs approximately equal to or less than the costs being incurred to-day in many parts of the world and the United States.

Removal of Solids

Because of fine passages provided for flow within the membrane stack, it is necessary to remove any significant amount of suspended solids from the feed-water. Most suspended material of an organic nature tends to adhere to the surfaces of the membranes, forming a slime. Deep well waters in general require no

filtration ; on occasion, silt or sand is entrained due to the pumping action, and rapid-sand filtration or settling is required. For most surface waters where colloidal material is found in suspension, coagulation and sand filtration is required. If the concentration of material is low, diatomite earth filtration is satisfactory.

It is generally found that the membrane stacks serve as a breeding ground for many kinds of bacteria found in non-sterile water. No significant attempt has been made to isolate the bacteria that are involved. If the feed-water and membrane system are initially free from bacteria, no build-up occurs. However, large multiplications will occur in the membrane stack if bacteria are present in the feed-water. Prechlorination to maintain a residual in the product water has solved the problem.

Waters containing 0·3 p.p.m. of iron or less have been successfully treated for thousands of hours without pre-treatment. Waters containing 1·0 p.p.m. of iron or more deposit a brown slime on the surfaces of the membranes which may eventually affect the performance of the system. The removal of the iron by oxidation (aeration or direct chlorination) and filtration is recommended if the iron concentration is about 1·0 p.p.m.

In the Middle East area, waters containing large amounts of iron (5 p.p.m.) and hydrogen sulphide (60 p.p.m.) were encountered. Much of the material was in the form of suspended iron sulphide ; the untreated water deposited an adherent black glossy film on the surface of the membranes which could be removed only by chemical treatment. Many membranes became brittle and ruptured under these conditions. It was necessary to remove this material from the feed-water : direct chlorination followed by filtration was the method used. A large installation would employ aeration-settling to reduce the chlorination-filtration load.

Removal of Scale

The majority of brackish waters encountered are supersaturated in calcium carbonate and many are close to being saturated in calcium sulphate. Since no significant heating of the water is involved during the demineralisation process, one might expect that no deposition of scale would result. Operation on brackish waters has shown that no scaling normally occurs on the membrane surfaces bounding the diluting stream; however, calcium carbonate scale does form on the side of the anion membrane facing the concentrating stream. No scaling of the cation membrane has been experienced. The scaling of the anion membrane appears to be a pH controlled phenomenon which seems to be almost independent of the blow-down rate.

The calcium carbonate scaling problem has been solved relatively simply by the continuous feeding of sulphuric acid to the blow-down stream to reduce the concentration of bicarbonate ions. No change in pH of the diluting stream occurs, and a pH change of about 0·5 unit occurs on the concentrating stream. Approximately one pound of concentrated sulphuric acid per 1000 gallons of demineralised water is the average acid consumption. From a financial point of view, this amounts to 1 to 2 cents per 1000 gallons, which is a negligible cost factor. Not only does the addition of acid in this manner prevent scaling, but it also effectively removes scale from plants even after weeks of accumulation.

Calcium sulphate scaling has been less serious and can be completely controlled by providing adequate blow-down. It has been found possible to operate continuously with a blow-down stream approximately 20 per cent supersaturated in calcium sulphate. When calcium sulphate precipitation does occur, it forms as a non-adherent material within the flow passages of the concentrating stream which is easily removed by flushing.

Florida Field Tests

It is of interest to note that early last year, the firm conducted a field test on its model " 300 B " demineraliser at the Patrick Air Force Base, near Cocoa Beach, Florida. A virtually inexhaustible supply of brackish water containing approximately 1600 p.p.m. total dissolved solids underlies this base, which is situated on a narrow sandy island completely surrounded by sea water. The purpose of this field test was to indicate the reliability and operating requirements of such equipment in continuous operation on the actual water existing at this site. The unit was operated over most of the demonstration period to produce water containing 500 p.p.m. of solids. Approximately 230,000 gallons of water were produced at this salinity. For other periods of intermediate length, the unit was also operated to produce 850 p.p.m. water and 300 p.p.m. water from the same source.

Over the test period the down-time for maintenance was negligible. The operating labour consisted of ten minutes daily for filter cartridge replacement and one hour weekly for chemical make-up. Neither of these labour requirements would be significant in large-scale plant operation, where automatic control of filtration and chemical make-up would be provided. A complete chemical analysis of the treated water is shown in the following table. This chemical analysis indicates that the overall demineralisation with respect to total dissolved solids was 71 per cent.

Water Analyses Before and After Treatment at Patrick Air Force Base

	Before, p.p.m.	After, p.p.m.	Removed, per-cent
Total dissolved solids at 103 deg. Cent.	1566	455	71
Total hardness as $CaCO_3$	546	145	73
Alkalinity as $CaCO_3$	108	66	38
Iron, Fe	0	0	0
Sulphate, SO_4	172	94	45
Chloride, Cl	612	159	74
Calcium, Ca	118	29	75
Magnesium, Mg	61	18	70
Fluoride, F	0·25	0·15	40

Large-Scale Plants

As a result of such simple tests as that conducted at the Patrick Air Force Base, it is possible to predict accurately the size, energy consumption and both operating and investment costs of any larger plant based on the same membrane stack. There is no scale-up factor involved in the basic unit, the stack, since this same stack is used both in the very small test plant and in a very large plant processing 2,000,000 gallons per day Such a large plant would have a flow rate of approximately 1400 gallons per minute of purified water and would require 70 standard stacks in parallel, each having a capacity of 20 gallons per minute. The required reduction of 1600 to 500 p.p.m. (a 69 per cent demineralisation) can be done in two stages of demineralisation, so that the total plant would contain 140 stacks. The installed price of this plant including buildings, all pumps, pipes, valves, labour of erection, engineering charges, contractor's fees, contingencies and stacks themselves, is estimated at 1,400,000 dollars. The plant would produce 500 p.p.m. water at a total cost of 42 cents per 1000 gallons.

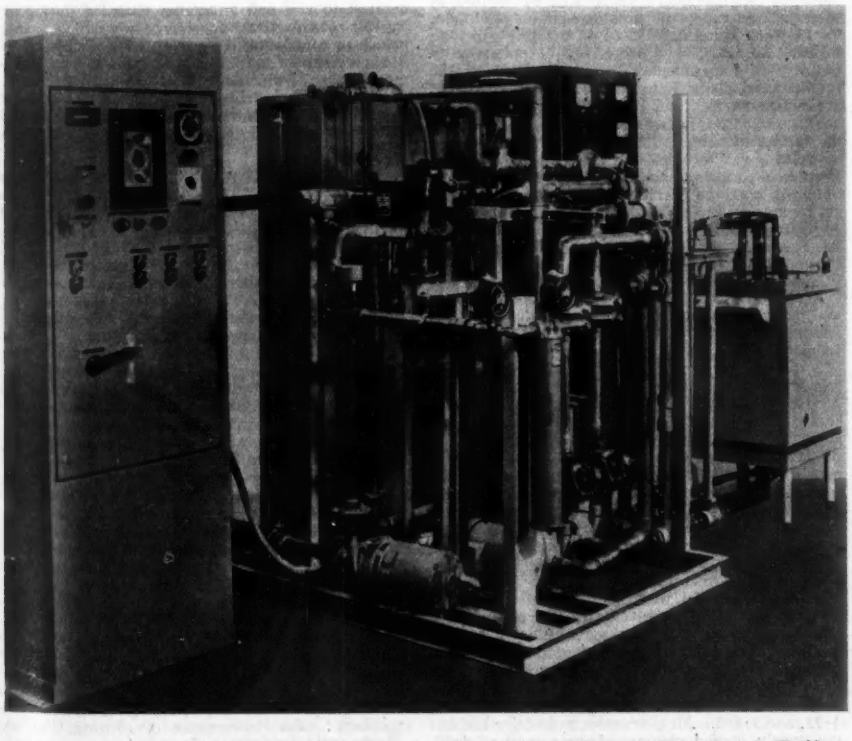


Fig. 6—Model " 300B " " Ionics " demineraliser on field test at the Patrick Air Force Base in Florida

Development of a Nuclear Ship Propulsion System

The U.S. Atomic Energy Commission and the U.S. Maritime Administration recently extended an invitation to American industry to submit proposals to develop a nuclear power plant, suitable for propelling merchant ships, consisting of a gas-cooled reactor coupled with a closed-cycle gas turbine. This action is a continuation of a joint long-range programme aimed at the development of advanced reactor systems for commercially competitive propulsive power of ships in the U.S. Merchant Navy. As part of this development programme, studies of the feasibility of nuclear propulsion of gas-cooled, closed-cycle systems have been completed by the General Motors Corporation, the Ford Instrument Company and General Atomic, a Division of the General Dynamics Corporation. It is concluded that further work should be undertaken to verify the high promise of this system.

From among those who submit proposals it is intended that a contractor will be selected to carry out necessary development work to arrive at a firm design for a land-based prototype plant. A balanced research and development effort, building on existing reactor technology, should make possible the construction of such a prototype plant within five to seven years from the award of the initial development contract. The long-range development programme is in addition to the work now progressing on the development and construction of the first nuclear-powered merchant ship, which was announced by the President on October 15, 1956. The Babcock and Wilcox Company is carrying forward work under a 10,000,000-dollar contract to supply major components of the pressurised-water nuclear propulsion plant for this ship. A preliminary design of the vessel itself has been completed and it is anticipated that a contract for its construction will be awarded in the next few months. The ship is scheduled for operation in 1960.

Personal and Business

Appointments

MR. V. B. HESSEN, A.M.I.E.E., has been appointed manager of the atomics division of Pye, Ltd.

MODERN ENGINEERING (BRISTOL), Ltd., has announced the appointment of Mr. D. Jubb as a technical director.

MR. G. F. LAURENCE has been appointed personal assistant to Mr. M. Goldsmith, chairman and managing director of Metalastik, Ltd.

METAL INDUSTRIES, Ltd., has announced that Mr. A. L. Mackenzie and Vice-Admiral Sir Frank Mason have been appointed directors. Mr. G. D. Belsham has resigned his position as managing director of Brookhirst Switchgear, Ltd., and has been appointed technical adviser to the Metal Industries group.

JOHN LAING AND SON (HOLDINGS), Ltd., and HOLLOWAY BROTHERS (LONDON), Ltd., have announced the following appointments to the Holloway board :—E. C. Uren, chairman ; W. M. Johnson, deputy chairman ; D. P. Marriott, F. S. Hockaday, E. R. Beecher, and H. E. Hodgson, directors.

Business Announcements

PULTRA, Ltd., states that the address of its head office is now 25, Manchester Square, London, W.1 (telephone, Welbeck 7941).

MR. NOEL SLATER, chief chemist and metallurgist of Spear and Jackson, Ltd., has retired after thirty-seven years' service with the company.

WICKMAN, Ltd., states that the address of its Newcastle office has been changed to Norham House, 12, New Bridge Street, Newcastle upon Tyne, 1.

EXPANDITE, Ltd., has announced the formation of a subsidiary company, Expandite (Ireland), Ltd., Greenhills Road, Walkinstown, Dublin (telephone, Dublin 501512).

THE BRITISH TYRE AND RUBBER COMPANY, Ltd., states that Mr. E. N. Lowe, senior export executive, will leave the United Kingdom on September 8 for a business tour of Canada.

MR. HENDRIE OAKSHOTT, treasurer of the household, and a Government whip, is visiting South Africa in September to represent the United Kingdom Government during the British Trade Weeks which will take place at Johannesburg from September 16 to September 28.

HEAD WRIGHTSON AND CO., Ltd., states that it has made an agreement with Compagnie de Fives-Lille, S.A., of Paris and Lille, covering the manufacture and sale in France by Fives-Lille of the ironmaking equipment designed and manufactured by Head Wrightson in conjunction with Arthur G. McKee and Co., of Cleveland, Ohio, U.S.A.

ELLIOT EQUIPMENT, Ltd., has announced that it has appointed Cory Brothers and Co., Ltd., as sole distributor in the United Kingdom of its inflatable life-saving equipment and other products, in addition to the appointment already held for overseas distribution. The headquarters of the overseas marketing organisation for Elliot Equipment, Ltd., is Cory Brothers and Co., Ltd., Corys' Buildings, Cardiff, and for United Kingdom inquiries, 8, Great Tower, London, E.C.3.

Miscellanea

EXHIBITION OF HEATING EQUIPMENT.—Two exhibitions of heating equipment for offices, factories and industrial establishments are being held by Weatherfoil Heating Systems, Ltd. (Dravo Division), 19, Berkeley Street, London, W.1. The first of these exhibitions will be held at the Birmingham Exchange and Engineering Centre from Tuesday, September 24 to Thursday, September 26 ; and the second at the East Room, McLellan Galleries, Glasgow, from Tuesday, October 1 to Thursday, October 3.

INTERNATIONAL CONFERENCE ON RADIOISOTOPES IN SCIENTIFIC RESEARCH.—The International Conference on Radioisotopes in Scientific Research, convened by Unesco, will be held in Paris from September 9 to 20, 1957. After an inaugural session in the Grand Amphitheatre of the Sorbonne, the remainder of the conference will take place in the Ecole de Medecine, rue des Sts. Péres, Paris. Sir John Cockcroft is to preside. The conference is to be strictly scientific in character. The programme and other details are to be announced later.

FILMS TO PROMOTE BRITISH ATOMIC PRODUCTS.—The overseas distribution rights of "British Atomic News," the first film of a series for the world promotion of British atomic products and services, have been acquired by the Central Office of Information on the recommendation of the Board of Trade. There will be both English and foreign language versions. British Atomic News, No. 1, runs for half-an-hour and is in Eastmancolour. Further productions in the series will also cover electronics, instrumentation and automation.

GAS-TIGHT SEAL FOR ELECTRICAL LEADS.—Certain Kelvin Hughes aircraft gyroscopes are totally enclosed in a gas-tight case, filled with helium. Lead-in wires to the electrically-driven gyro have to be passed through the case without causing leakage. Nine finely drawn copper tubes, partly filled with solder, are led through the neck of a brass ferrule and "potted" into position with synthetic resin. Wires can be easily soldered to the tubes. Tests in a hydrogen ionisation chamber at a high vacuum are claimed to have shown no leakage after repeated changes of temperature ranging from −40 deg. Cent. to +70 deg. Cent. It is stated that the seal is capable of withstanding mechanical and thermal shock, and is suitable for temperatures up to +100 deg. Cent.

WATER RESOURCES IN ASIA AND THE FAR EAST.—The United Nations' Economic Commission for Asia and the Far East has published three further volumes (Nos. 9. 10 and 11) in its flood control series, which are entitled as follows :—No. 9, *Proceedings of the Regional Technical Conference on Water Resources Development in Asia and the Far East ;* No. 10, *Glossary of Hydrologic Terms Used in Asia and the Far East ;* No. 11, *Water Resources Development in Burma, India and Pakistan.* The first of these three volumes contains the proceedings of the conference held in Tokyo in May, 1954, at which a large number of papers were presented, under the headings of : "Economic and Social Aspects," "Hydrological Problems," "Hydraulic Structures," "Control of Sediment," "Progress of Multi-Purpose Projects," and "Organisation for Development of Water Resources." The last of the three volumes reviews the water resources of the countries named, their present stage of development, and the future needs and special problems involved in further development.

FLAME RESEARCH.—On October 9, 1957, at the Institution of Civil Engineers, the British Flame Research Committee and the Institute of Fuel are to hold a symposium on "Flames and Industry." The papers presented will deal not only with further results of research on flame radiation, but also with the significance in practice of these results in various industrial applications. These will be treated in separate short papers to be discussed in the afternoon, the morning being devoted to an opening paper on "Flame Research," and one on the "Application in Industry of Experimental Techniques used by the International Flame Research Foundation." Besides the two papers mentioned above, papers dealing with heat transfer from flames will be given, as applied in the various industries : steel, glass, cement, oil, and in boilers, gas turbines and in furnaces generally. Enrolment forms and advance sets of papers may be obtained from the Secretary, The Institute of Fuel, 18, Devonshire Street, Portland Place, London, W.1 ; any further details, or enrolment forms only, from the Secretary, British Flame Research Committee, 11, Park Lane, London, W.1.

VEHICLE TRANSMISSION.—A new gearbox for goods and passsenger vehicles has been introduced by the Automobile Gearbox Division of David Brown Industries, Ltd., Park Works, Huddersfield. The 552 model will replace the 045 and 45 units with forward and forward mounted centre control respectively, and also be available with direct centre control : it has a maximum torque of 270 lb ft. In contrast to the synchromesh gearbox described on January 4 last, page 15, the transmission has a cast iron casing into which the bearings can be pressed directly : the light alloy gearbox uses steel liners to avoid a heavy interference fit and locates them with the cover bolts. Single covers are provided at the end and on top, instead of the case being split. Constant mesh gears are used for the four higher ratios, sliding gears for first and reverse : the arrangement is conventional, with the main shaft on top and spigoted into the main drive gear. The shift pattern is the conventional one for three selectors where top is direct, but the overdrive box has fourth and fifth transposed. In all cases the change from first to second is 1·8 : the overdrive box rises 1·97 and 1·84 followed by 0·756 and the underdrive 1·62, 1·75, and 1·602. An alternative underdrive box has the evenly graded changes above second of 1·52, 1·52 and 1·575. Two detachable bell housings are available, one S.A.E. 3 and the other to suit the "4 L.W." Gardner engine.

VEHICLE REGISTRATIONS.—The August, 1957, Monthly Statistical Review of the Society of Motor Manufacturers and Traders, Ltd., includes record of vehicles registered for the first time in Great Britain during the first six months of 1957. The cars are classified by capacity ; the classes including over 1000 vehicles were as follows (typical vehicles of each class are mentioned in parentheses), each division of one decilitre being denoted by a median figure :—55,383 vehicles of 950 c.c. ("A" series B.M.C., Standard "10"); 37,904 vehicles of 1150 c.c. (1172 Ford, Volkswagen) ; 24,781 vehicles of 1450 c.c. ("B" series B.M.C.) ; 15,204 vehicles of 1350 c.c. (Hillman "Minx") ; 13,590 vehicles of 1750 c.c. (Ford "Consul") ; 10,659 vehicles of 1550 c.c. (Vauxhall "Wyvern") ; 7838 vehicles of 2250 c.c. (Vauxhall "Velox"' Sunbeam) ; 7483 vehicles of 2550 c.c. (Ford "Zephyr") ; 7374 vehicles of 2650 c.c. ("C" series B.M.C., Rover "90") ; 6724 vehicles of 850 c.c. (Standard "8") ; 2892 vehicles of 2450 c.c. (Jaquar 2·4, Riley 2½) ; 2716 vehicles of 1250 c.c. (Hillman "Husky") ; 2618 vehicles of 2050 c.c. (Standard "Vanguard," Rover "75") 1980 vehicles of 1950 c.c. (Rover "60") ; 1836 vehicles of 3450 c.c. (Jaguar 3·4) ; and 1180 vehicles with engines not exceeding 300 c.c. (B.M.W. "Isetta"). The distribution of registrations during June, 1957, was similar, except that the 1550 c.c. class (Vauxhall "Victor") was fourth instead of sixth, with 9·1 per cent instead of 5·2 per cent of the total.

AERIAL GEOPHYSICAL SURVEY IN CORNWALL.—Last year, Hunting Geophysics, Ltd., introduced a D.C.3 aircraft, especially modified to carry magnetometer, electro-magnetic detector and scintillation counter, all three of which may be operated simultaneously. This aircraft has since been engaged on contract work. It has recently been carrying out a survey in Cornwall over the area from Land's End to a North-South line, Bude to Polperro, entailing a total of 4300 line miles. This contract was given by the Department of Scientific and Industrial Research on behalf of the Geological Survey of Great Britain in association with the U.K. Atomic Energy Authority. In this survey, by working a reduction unit on the shift system at the flying base, it was possible to relate radiometric anomalies to the ground within twenty-four hours after each flight, so that investigation of the more obvious radiometric anomalies could be made immediately by the client's ground parties in Land Rovers. The sensitivity of the radiometric instruments was proved conclusively, the firm states, as all previously known radioactive anomalies in the area were picked up. This would naturally give added interest to any new anomalies recorded during the survey. Cornwall was considered a suitable area over which to conduct such a survey, not only because of the presence of sulphide and uranium-bearing deposits, some of which might not have been discovered, but also—and perhaps more important—because it would serve as a testing ground in the technique of discovery to be adopted for less well-known areas overseas.

THE BRITISH INSTITUTION OF RADIO ENGINEERS PREMIUM AWARDS.—The British Institution of Radio Engineers has announced the following awards of premiums to authors of papers in 1956. The Clerk Maxwell premium is made to K. D. Froome, Ph.D. (Metrology Division, National Physical Laboratory), for his paper, "Microwave Determinations of the Velocity of Light." The Heinrich Hertz premium, awarded for the most outstanding paper on the mathematical or physical aspect of radio, goes to A. G. Edwards, Ph.D. (A.E.I. Research Laboratories), for his paper, "The Effects of Atmospherics on Tuned Circuits." The Brabazon premium for the most outstanding contribution on radio and electronic devices for aircraft safety is awarded to K. E. Harris, B.Sc. (director of research, Cossor Radar, Ltd.), for his paper, "Some Problems of Secondary Surveillance Radar Systems." The Louis Sterling premium for the most outstanding paper on television technique is awarded to A. van Weel, Dr. Techn. Sc. (Philips Research Laboratories, Eindhoven, Holland), for his paper, "Some Remarks on the Radio-frequency Phase and Amplitude Characteristics of Television Receivers." The Marconi premium for the most outstanding engineering paper is awarded to Professor P. M. Honnell, Ph.D. (Washington University, St. Louis, U.S.A.), for his paper, "Prescribed-Function Vibration Generator." The Dr. Norman Partridge Memorial Award dealing with improvements in the quality of sound reproduction is made to H. J. Leak for his paper, "High Fidelity Loudspeakers : the Performance of Moving Coil and Electrostatic Transducers."

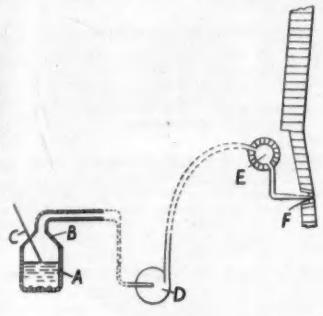
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

METALLURGY

781,116. April 29, 1955.—THE TREATMENT OF FUMES IN STEEL-MAKING OPERATIONS, The British Oxygen Company, Ltd., Bridgewater House, Cleveland Row, St. James's, London, S.W.1. (*Inventors: Leonard Charles Bannister and William John Badenoch Chater.*)

The invention relates to a process and apparatus for the treatment of fumes arising during steel-making operations and more particularly to the treatment of the brown fumes arising when molten metal is treated with oxygen, such as, for example, the blowing of oxygen into metal in a ladle. Its object is to



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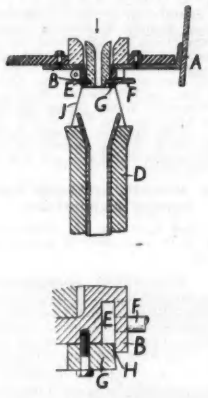
provide a method of and apparatus for removing and disposing of these fumes, for utilising the iron which they contain in suspension and also for utilising any excess oxygen which may also be present. As will be seen from the drawing, the ladle *A*, containing the molten iron, is provided with a conical hood *B*, joined to the rim of the ladle in gastight manner by a refractory seal. An oxygen lance *C* for directing a jet of oxygen or oxygen-enriched air against the molten iron, passes through the wall of the hood. A conduit into the apex of the hood is connected at the other end to the inlet of a blower *D*. The outlet of the blower is connected by a further conduit with the bustle pipe *E* of a blast-furnace. From the bustle pipe the usual pipes for conducting the blast lead to tuyeres *F* in the wall of the blast-furnace. In operation, fumes arising from the action of the oxygen from lance with the molten iron in the ladle are confined within the hood. They are withdrawn by the blower and delivered under a slightly increased pressure to the bustle pipe. Here they are mixed with the normal hot blast and passed into the furnace through the tuyeres. A blast-furnace is a very efficient means of exchanging heat and because of the large surface of the charge the small quantity of iron oxide in the fumes introduced with the hot blast will be trapped in the descending charge of the furnace. If excess oxygen is present in the fumes removed from the hood, it will assist to maintain the temperature in the blast-furnace. Although the total weight of iron oxide added with the fumes would not be expected to exceed 5 to 10 per cent of the total output of the blast-furnace, the whole of this will probably be recovered as iron.—*August* 14, 1957.

780,004. May 22, 1951.—COPPER-ALUMINIUM ALLOY, N. C. Ashton, Ltd., St. Andrew's Road, Huddersfield. (*Inventor: John Philip Dennison.*)

This invention relates to copper-base alloys of the single-phase (alpha) copper-aluminium type. It more particularly concerns an improved quaternary copper-base alloy containing aluminium, cobalt and nickel, in which the nickel may be substituted in whole or in part by manganese, which, by virtue of its precipitation hardening characteristics, is capable of providing articles having high resistance to creep at temperatures up to and including 500 deg. Cent. Due to these precipitation hardening characteristics the alloy also possesses very good mechanical properties at ordinary temperatures. The alloy according to the invention is composed of 5·5 to 8 per cent aluminium, 1 to 2 per cent cobalt, and 2 to 6 per cent nickel, the balance being copper and usual impurities and the nickel being replaceable in whole or in part by an equal weight of manganese. The alloy after the treatment described below exhibits exceptionally high resistance to creep, high mechanical properties, and is capable of being worked either hot or cold. These characteristics render the alloy suitable in particular for use as second-stage gas turbine heat interchanger tubes or for gas turbine compressor blades. Preferred proportions in which to alloy the aforesaid metals are: Aluminium 7 per cent, cobalt 1·5 per cent, nickel 4 per cent, the balance being copper and usual impurities. In preparing samples of the alloy for tests, the metals were melted together in the conventional manner, and billets were cast 8in by 6in by 1¼in. The test specimens were prepared by hot rolling into suitable strip at temperatures between 800 deg. and 900 deg. Cent., followed by heat-treatment. The heat-treatment may consist of a solution treatment between 850 deg. and 1000 deg. Cent., and the cooling rate being critical depends on the thickness of cross section of the material. This may involve air cooling or quenching in water. For instance, to obtain optimum properties, materials exceeding ¼in in thickness should be water quenched, and materials having a thickness not exceeding ¼in should be air cooled. The material may be precipitation hardened in the range 400 deg. to 600 deg. Cent., either directly or following cold work. After cold work, for certain purposes, the precipitation hardening may be omitted. —*July* 31, 1957.

781,276. June 15, 1954.—THE CASTING OF METALS, Stewarts and Lloyds, Ltd., 41, Oswald Street, Glasgow, C.1. (*Inventor: William Anderson Smith.*)

The invention enables the molten metal to be shielded from the ambient air by an inert gas in the passage of the metal from the ladle into the mould.



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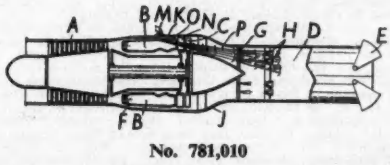
It also gives access to the ladle outlet when required between the mould in top pouring or between the usual trumpet in bottom pouring for the purpose of cleaning the outlet. In the drawing *A* denotes the ladle, *B* the outlet stopper box at the bottom of the ladle, and *D* the usual trumpet that is employed for bottom pouring of the molten metal from the ladle into the ingot mould. When bottom pouring the top of the mould may advantageously be closed by a cover-plate having a restricted outlet. The stopper box of the ladle is modified so as to afford in the box casting *B* an unnular space *E* to which an inert gas can be supplied via a tube *F*. The bottom end of this casting is equipped with a plate *G* which leaves an annular orifice *H* (see lower view) for the outlet of the gas, and the peripheral wall of the plate below the orifice is tapered so that the gas issuing from the orifice forms a truncated conical curtain as indicated by *J* about the stream of metal issuing from the ladle and between the ladle outlet and the top of the trumpet *D* in the case of bottom pouring or the top of the mould in the case of top pouring.—*August* 14, 1957.

GAS TURBINES

781,010. February 22, 1955.—EXHAUST REHEAT EQUIPMENT, Société Nationale D'Etude et de Construction de Moteurs D'Aviation, 150 Boulevard Haussmann, Paris, France.

The invention relates to an improvement in exhaust reheat devices for gas turbine engines, and more particularly in after-burning devices for turbo-jet units. As shown in the drawing, *A* is the air compressor of the turbo-jet unit, *B* the combustion chambers, *C* the gas turbine, and *D* the reaction



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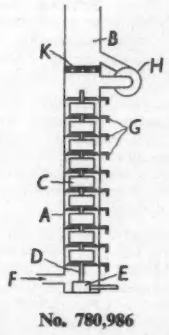
discharge nozzle provided with arrangement *E* for controlling the effective cross-section of its outlet orifice. The combustion chambers are supplied with fuel by means of the burners *F*, whilst, in the exhaust conduit of the turbine, there is mounted an after-burning injection system *G* followed by a flame-holder *H* for stabilising the flame. The combustion chambers have walls slightly spaced apart from those of the casing *J* of the engine, so as to form a conduit *K* enabling the circulation of secondary cooling air around the combustion chamber. Lateral openings in the walls of the combustion chambers permit a part of this secondary air to pass into the chambers and dilute the burnt gases before they pass into the turbine. In conformity with the invention, one or a number of injectors *M* is arranged in one or a number of combustion chambers in the vicinity of the nozzle guide-vanes *H* of the turbine. This injector is arranged to produce a strongly concentrated jet *O* of fuel which is directed towards the nozzle guide-vanes *N*. This jet, by reason of its high velocity, entrains part of the secondary air which thus forms around it a protective cold sheath which prevents direct contact of the fuel forming the jet *O* with the hot gases generated by the combustion chamber, and thus avoids any risk of general ignition of the fuel on the upstream side of the turbine *C*. This jet, which passes through the nozzle guide-vanes and the blades of the turbine, is subjected to a considerable turbulence which ensures intense atomisation and vaporisation of the fuel, so that when it is discharged from the turbine it is atomised and in intimate contact with the hot exhaust gases from the turbine in a zone at which the gases have still a fairly high temperature. This contact ensures the ignition of the fuel and there is formed a flame *P* which reaches the after-burning injectors *G* and, preferably, even as far as the flame-holder *H*. In its turn, this flame ensures infallibly the ignition of the fuel from *G*. The fuel discharged from the injector does not burn in the combustion chamber *B*, and there is thus no increase in temperature on the upstream side of the turbine, and the injection period may be prolonged to any desired extent, and even for the whole period of operation of the after-burning system. Furthermore, it is not necessary to provide complicated devices for controlling the quantity of fuel delivered, since the latter has simply to be sufficient for the flame *P* produced on the downstream side of the turbine to be long enough to reach the after-burning injectors *G* and preferably the flame-holder *H*. These after-burning injectors could even be dispensed with, the total quantity of supplementary fuel being then supplied by the injectors *M*.—*August* 14, 1957.

STEAM GENERATORS

780,986. October 11, 1954.—REMOVAL OF DUST PARTICLES FROM GASES, The Metropolitan-Vickers Electrical Company, Ltd., St. Paul's Corner, St. Paul's Churchyard, London, E.C.4. (*Inventor: Arthur John King.*)

The invention relates to a method of and apparatus for the removal of dust particles from gases, and has an important application in the removal of particles from flue gases, its object being to provide a convenient and economical method of precipitation of



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particles in a gas. Apparatus for carrying out the invention comprises a settling chamber, means for passing a stream of gas along the chamber, means for producing standing sound waves in the chamber so as to cause settling of suspended particles at the antinodes of the sound waves, means for removing the settled particles from the chamber and means for leading gas into and out of the chamber at positions corresponding to single antinodes of the standing waves. The drawing shows a sectional elevation of a vertical shaft *A* embodying the invention mounted on the base of a chimney stack *B*. It may, if desired, be mounted separately. The shaft has a series of vanes *C* mounted on a central spindle *D* and rotated via a gearbox *E* and driving spindle. These vanes, by centrifugal action, cause the particles to be deposited on the walls of the shaft. The particles thus deposited may be carried by water running down the walls into gulleys *G* between the vanes. Additionally, the outlet at the top of the shaft may lead to a centrifugal separator *H* through which the gas may pass before leaving the chimney stack. The gas carrying the suspended particles is fed into the shaft at inlet *F*, situated one (or an odd number of) quarter wavelengths from the base. Loudspeakers *K* produce standing sound waves in the shaft.—*August* 14, 1957.

Launches and Trial Trips

RONA, shelter deck cargo ship ; built by Hall, Russell and Co., Ltd., for the Colonial Sugar Refining Company, Ltd.; length between perpendiculars 365ft, breadth moulded 54ft 6in, depth moulded 34ft 9in, deadweight 6600 tons on 23ft 6in draught ; four holds, one 25-ton, one 15-ton and twelve 5-ton derricks, electric deck machinery ; three 180kW diesel-driven generators ; Ailsa-Doxford opposed piston, two-stroke oil engine, 3000 b.h.p. Trials, June.

VITRINA oil tanker ; built at Belfast by Harland and Wolff, Ltd., to the order of Shell Tankers, Ltd.; length between perpendiculars 635ft, breadth moulded 84ft 3in, depth moulded 46ft 3in, deadweight 32,000 tons ; thirty cargo oil compartments, one main cargo pump room, one 550kW, 450V, 60 c/s mixed-pressure turbo-alternator, and one 550kW constant-pressure turbo-alternator, one 150kW diesel-driven alternator ; one set of double reduction geared compound turbines, 13,000 service s.h.p. at 105 propeller r.p.m., two Babcock and Wilcox water-tube boilers supply steam at 600 lb per square inch and 850 deg. Fah. Trial, July 4.

BRITISH VALOUR, oil tanker ; built at Wallsend by Swan, Hunter and Wigham Richardson, Ltd., for the B.P. Tanker Company, Ltd.; length overall 680ft 1in, length between perpendiculars 640ft, breadth moulded 86ft, depth moulded 48ft, deadweight 32,025 tons on 35ft 1⅛in draught, service speed 15½ knots ; thirty oil cargo tanks, cathodic protection, one main cargo pump room, three 850 tons per hour Drysdale turbine-driven centrifugal pumps, three stripping pumps and one rotary pump ; two 600kW, 440V, geared turbine-driven alternators, one 150kW diesel-driven alternator and one 75kW steam-driven alternator ; one set of Wallsend double-reduction geared compound turbines, 15,500 service s.h.p. at 112 propeller r.p.m., two Babcock and Wilcox selectable superheat boilers provide steam at 600 lb per square inch and 850 deg. Fah. Trial, July 9.

ESSO BRIXHAM, coastal oil tanker ; built by Philip and Son, Ltd., for the Esso Petroleum Company, Ltd.; length between perpendiculars 185ft, breadth moulded 33ft, depth moulded 13ft 6in, deadweight 1070 tons ; four pairs of cargo oil tanks, two 253 tons per hour diesel-driven cargo oil pumps ; English Electric eight-cylinder, turbo-charged diesel engine, 900 b.h.p. at 750 r.p.m., driving through reverse reduction gear. Launch, July 10.

POLYXENE C, closed shelter deck cargo ship ; built at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., for Andria Maritima S.A., Panama ; length between perpendiculars 470ft, breadth moulded 63ft 6in, depth moulded to shelter deck 41ft 1in, deadweight 14,000 tons on 30ft 7in draught ; five cargo holds, one 30-ton, six 10-ton and four 5-ton derricks, electric winches ; three 180kW and one 50kW diesel-driven generators ; Swan, Hunter - Doxford diaphragm oil engine, five cylinders, 700mm diameter by 2320mm combined stroke, 6000 b.h.p. at 115 r.p.m. Trial, July 10.

FLAMANT ROSE, trawler ; built by Les Chantiers et Ateliers Augustin Normand for l'Armement Garnier de Lorient ; length 37·4m, breadth 7·2m, depth 4·05m, draught mean 3·38m, displacement 430 tons, speed 12 knots, Duvant diesel engine, 730 b.h.p. at 375 r.p.m., driving through reverse reduction gear. Launch, July 13.

VIRGINIA, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for Nueva Vista Compania Naviera S.A., Panama ; length overall 556ft 5in, length between perpendiculars 525ft, breadth moulded 71ft, depth moulded 39ft 3in, draught 30ft 6in, deadweight 18,025 tons, trial speed 15½ knots ; twenty-seven oil cargo tanks, one main cargo pump room, three 700 tons per hour turbine-driven centrifugal pumps, three 150 tons per hour vertical duplex stripping pumps, cargo mains 13in bore, deck lines 12in bore ; two 325kW turbine-driven generators, one 100kW diesel-driven generator ; one set of Richardsons Westgarth double-reduction geared turbines, 7300 s.h.p. at 100 propeller r.p.m., 8200 maximum s.h.p. at 104 propeller r.p.m., steam supplied at 450 lb per square inch and 750 deg. Fah. by two Foster-Wheeler " D " water-tube boilers. Trial, July.

AJAX, cargo and passenger liner ; built at the Naval Yard, Walker, of Vickers-Armstrongs, Ltd., for Alfred Holt and Co.; length overall 491ft 6in, breadth moulded 62ft, depth moulded 35ft 3in, deadweight 9000 tons, load draught 28ft ; six cargo holds ; Kincaid - B. and W. supercharged diesel engine, 8000/8500 b.h.p. Launch, July 24.

RUYSDAEL, cargo ship ; built by Smith's Dock, Ltd., for the Bolton Steam Shipping Company, Ltd.; length overall 461ft 11in, length between perpendiculars 435ft, breadth moulded 60ft 3in, depth moulded to upper deck 38ft 9in, deadweight 10,266 tons on 26ft 7½in draught at 13½ knots service speed ; five holds, three " Bipod " masts, ten 5-ton derricks, steam winches ; one 75kW steam-driven and one 75kW diesel-driven generators ; Hawthorn-Doxford opposed-piston, two-stroke diaphragm oil engine, four cylinders, 670mm diameter by 2320mm combined stroke, 4450 b.h.p. at 115 r.p.m. Trial, July.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Sept. 6.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, Chairman's Address, A. Robertson, 6.30 p.m.
Mon., Sept. 9.—CENTRAL LONDON BRANCH : White Hall Hotel, London, W.C.1, " District Heating," W. A. Gregory Carter, 6.30 p.m. ★ N.W. LONDON BRANCH: Century Hotel, Forty Avenue, Wembley Park, Chairman's Reception, Principal Guest E. A. Bromfield, 7.30 p.m.
Tues., Sept. 10.—N. LONDON BRANCH : Visit to the Long Distance Telephone Exchange, Faraday Building, 7 p.m. ★ OXFORD, READING AND DISTRICTS BRANCH : Agricultural Hall, 121, Oxford Road, Reading, " Hot Water and Heating from the Fridge," 7.15 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH : Wiltshire Lamp Hotel, Portsmouth, " Problems of Shop Lighting," K. G. White, 7.30 p.m.
Wed., Sept. 11.—BIRMINGHAM BRANCH : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, " Railway Electrification," J. Bagdzinski, 7.30 p.m. ★ GLASGOW BRANCH : Visit to Braehead Power Station, Renfrew, 7 p.m. ★ HALIFAX BRANCH : Crown Hotel, Horton Street, Halifax, " Fire Prevention by Nuclear Detection," A. S. Radford, 7.45 p.m. ★ NOTTINGHAM BRANCH : Nottingham Mechanics' Institution, Trinity Square, Nottingham, Chairman's Address, 7.15 p.m.
Thurs., Sept. 12.—S.W. LONDON BRANCH : Prince of Wales Hotel, London, S.W.19, " Some Applications of Electricity in a Large Modern Laundry," R. Appleyard, 8.30 p.m.

ENGINEERING, MARINE, WELDING AND NUCLEAR ENERGY EXHIBITION

To-day to Thurs., Sept. 6, *to Sept.* 12.—Olympia, Hammersmith Road, London, W.14, open daily 10 a.m. to 6 p.m., Fridays 10 a.m. to 8 p.m.

ENGINEERS' GUILD

Fri., Sept. 20.—S. WALES AND MONMOUTHSHIRE BRANCH : Old Arcade Inn, Church Street, Cardiff, Luncheon, 12.45 p.m.
Thurs., Sept. 26.—METROPOLITAN BRANCH : Caxton Hall, Caxton Street, Westminster, London, S.W.1, Annual General Meeting, Discussion on " The Aims and Future Policy of the Guild," 6 p.m.

INCORPORATED PLANT ENGINEERS

Mon., Sept. 9.—DUNDEE BRANCH : Mathers Hotel, Dundee, " Variable-Speed Drives with Voltage Regulation Equipment," 7.30 p.m. ★ MERSEYSIDE AND N. WALES BRANCH : The Blossoms, City Road, Chester, " The Cost Accountant and the Plant Engineer," R. G. Hall and B. J. Willson, 7.15 p.m.
Tues., Sept. 10.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, Chairman's " At Home," 7.15 p.m.
Wed., Sept. 11.—W. BRANCH : Grand Hotel, Bristol, " Fire Prevention in Industrial Buildings," 7.15 p.m.
Thurs., Sept. 12.—GLASGOW BRANCH : Scottish Building Centre, Glasgow, " The Design and Application of Rotary and Reciprocating Air Compressors," W. Scott, 7.15 p.m. ★ N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, " Internal Combustion Engines as Applicable to Plant Engineering," Norman Parry, 7 p.m.
Tues., Sept. 17.—BIRMINGHAM BRANCH : Hotel Leofric, Coventry, " Titanium as a Material of Construction in the Chemical Industry," K. W. J. Bowen, 7.30 p.m.
Wed., Sept. 18.—KENT BRANCH : King's Head Hotel, High Street, Rochester, Ladies' Film Evening, 7 p.m.
Thurs., Sept. 19.—BLACKBURN BRANCH : Golden Lion Hotel, Blackburn, Joint Meeting with Institute of Fuel, " Fuel and Power Position in the United Kingdom," Rear-Admiral Sir Sidney Frew, 7.30 p.m.
Tues., Sept. 24.—GLASGOW BRANCH : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, Joint Meeting with the Institution of Heating and Ventilating Engineers, " Steam," and " Combustion and the Chain Grate Stoker," 7.15 p.m. ★ S. WALES BRANCH : South Wales Engineers' Institute, Park Place, Cardiff, " Metal Degreasing by Trichloroethylene," and " Metal Pretreatment in Industry," 7.15 p.m.
Thurs., Sept. 26.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, " The Design of Rolling Mills, with particular reference to Hot and Cold Ferrous Mills," M. Langen, 7.30 p.m.
Fri., Sept. 27.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, " Some Principles of Radiant Heating," P. A. Coles, 7.30 p.m.
Mon., Sept. 30.—W. AND E. YORKSHIRE BRANCH : Leeds University, " The Safe Use of Electricity," J. J. Emerson, 7.30 p.m.
Tues., Oct. 1.—E. MIDLANDS BRANCH: County Hotel, Theatre Square, Nottingham, " The Heat Pump : Some Aspects of its Application," J. A. Sumner, 7 p.m. ★ EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, " Practical Plant Engineering in the Chemical Industry," C. W. Winstock, 7 p.m. ★ PETERBOROUGH BRANCH : White Lion Hotel, Church Street, Peterborough, " Hydro-Electric Power Development," G. C. Cummings, 7.30 p.m.
Wed., Oct. 2.—LEICESTER BRANCH : Bell Hotel, Leicester, " Factory Flooring," F. C. Harper, 7 p.m. ★ SOUTHERN BRANCH : Royal Beach Hotel, Portsmouth, " The Engineer and the Clean Air Act," E. C. Rogers, 7.30 p.m.
Tues., Oct. 8.—MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, " Chain Grate Stokers," C. H. G. Hayward, 7.15 p.m.
Thurs., Oct. 10.—GLASGOW BRANCH : Scottish Building Centre, 425–427, Sauchiehall Street, Glasgow, " The Measurement and Prevention of Smoke from Industrial Boilers," T. F. Hurley, 7.15 p.m. ★ MANCHESTER BRANCH AND MERSEYSIDE AND N. WALES BRANCH : Joint Meeting, Aboard Clubship " Landfall," " What Purpose does Incorporated Plant Engineers Serve ? " 7.15 p.m. ★ N.E. BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, " The Manufacture of Tubes," H. B. Elliot, 7 p.m.
Mon., Oct. 14.—DUNDEE BRANCH : Mathers Hotel, Dundee, " Boiler Feed Systems and Auxiliaries," J. R. Cairns, 7.30 p.m.
Wed., Oct. 16.—KENT BRANCH : Kings Head Hotel, High Street, Rochester, " The Generation of Power from Atomic Energy," H. R. M. Hyder, 7 p.m.
Thurs., Oct. 17.—BLACKBURN BRANCH : Golden Lion Hotel Blackburn, " Man Management," A. Roberts, 7.30 p.m.
Fri., Oct. 18.—BIRMINGHAM BRANCH : Imperial Hotel, Lower Temple Street, Birmingham, Mobile Plant Discussion Group, " Planned Maintenance on Equipment on Building Sites," Walter T. Scopes, 7.30 p.m.
Tues., Oct. 22.—S. WALES BRANCH : South Wales Engineers' Institute, Park Place, Cardiff, Films on " Methods of Mechanical Application," " Reclamation of Oil," and " Conservation of Grade," 7.15 p.m.
Thurs., Oct. 24.—LONDON BRANCH : College of Preceptors, Bloomsbury Square, London, W.C.1, " Complexity of Plant and the Training of Operatives," N. D. Pirrie, 7 p.m.
Mon., Oct. 28.—WEST AND EAST YORKSHIRE BRANCH : Leeds University, " Thermoplastics, with particular reference to their Application in Tube Manufacture and Usage," J. Aldred, 7.30 p.m.
Thurs., Oct. 31.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, " The Radar Telescope," H. C. Husband, 7.30 p.m.

INSTITUTE OF FUEL

Wed., Oct. 9.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Symposium on " Flames and Industry," 10 a.m.

INSTITUTE OF METALS

Mon. to Fri., Sept. 16 *to* 20.—Forty-ninth Annual Autumn Meeting, 1957, to be held in Glasgow.

INSTITUTE OF PHYSICS

Tues. to Thurs., Sept. 10 *to* 12.—ELECTRON MICROSCOPY GROUP : University College of North Wales, Bangor, Annual Conference.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Sept. 11.—E. MIDLANDS CENTRE : Day Visit to the Works of Leyland Motors, Ltd., Leyland, Lancs.
Wed., Sept. 18.—S. WALES CENTRE : Afternoon Visit to the Works of Pilkington Glass Company, Pontypool, Monmouthshire. ★ METROPOLITAN AREA : Afternoon Visit to the Motor Repair Centre of Shell-Mex and B.P., Ltd., Fulham, London, S.W.6.

INSTITUTION OF ENGINEERING DESIGNERS

Mon., Sept. 9.—N.E. BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, Chairman's Address, Informal Discussion on Branch Affairs, 7.15 p.m.
Mon., Oct. 14.—N.E. BRANCH : Northern Architectural Association Hall, 6, Higham Place, Newcastle upon Tyne, " Building Structures," G. Gladstone, 7.15 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Fri., Sept. 20.—LONDON BRANCH : Institution of Civil Engineers, Great George Street, London, S.W.1, " Pavement Construction on Christmas Island," V. J. M. Smith and R. Airey, 5.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Sept. 25.—GENERAL MEETING : Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, E. S. Cox, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Sat., Sept. 14.—SOUTHERN BRANCH : Whole-day visit to the Greenham Common Base of the United States Air Force, Newbury, Berks, 10 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

Wed., Sept. 18.—BIRMINGHAM SECTION : College of Technology, Gosta Green, Birmingham, 4, Film Evening, 7 p.m. ★ WOLVERHAMPTON GRADUATE SECTION : Wolverhampton and Staffs College of Technology, Wulfruna Street, Wolverhampton, " Nimonic Presswork," J. A. Grainger, 7.30 p.m.
Tues., Sept. 24.—OXFORD SECTION : Town Hall, Oxford, " Transfer Pressing," 7.30 p.m.
Wed., Sept. 25.—SHREWSBURY SECTION : Shrewsbury Technical College, Shrewsbury, " British Clock and Watch Production," R. Lenoir, 7.30 p.m.
Thurs., Sept. 26.—NORWICH SECTION : Norwich City College, Ipswich Road, Norwich, " S.G. Iron—A Versatile Engineering Metal," W. W. Braidwood, 7 p.m.
Fri., Sept. 27.—LEICESTER SECTION : Grand Hotel, Leicester, " Work Measurement and Its Uses for Management," W. Hewett, 7 p.m.
Fri., Oct. 4.—Dorchester Hotel, Park Lane, London, W.1, Annual Dinner.

IRON AND STEEL INSTITUTE

Tues., Sept. 24.—4, Grosvenor Gardens, London, S.W.1, Autumn General Meeting, 10.45 a.m., to be followed by a Lecture at the Royal Institution, Albemarle Street, London, W.1, " The Future Engineering Development of the Gas-Cooled Nuclear Reactor," J. M. Kay, 6 p.m.
Wed. and Thurs., Sept. 25 *and* 26.—IRON AND STEEL ENGINEERS' GROUP : Church House, Westminster, London, S.W.1, " Air Pollution in the Iron and Steel Industry."

MANCHESTER GEOLOGICAL AND MINING SOCIETY

Thurs., Oct. 10.—Mining and Technical College, Wigan, Annual General Meeting, 3.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Mon. to Thurs., Sept. 9 *to* 12.—Hotel Metropole, Folkestone, The Sixth Anglo-American Aeronautical Conference.
Fri., Sept. 13.—FORTY-FIFTH WILBUR WRIGHT MEMORIAL LECTURE : Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, " Advanced Education and Academic Research in Aeronautics," Clark B. Millikan, 6 p.m.

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed. to Fri., Oct. 2 *to* 4.—Palace Hotel, Southend-on-Sea, Autumn Meeting.

SOUTH WALES INSTITUTE OF ENGINEERS

Tues. and Wed., Oct. 29 *and* 30.—Park Place, Cardiff, Centenary Celebrations.

Advanced Engineering Courses

Liquid Fuels and Fuel Plant Technology. SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3. Course commencing September 23, Monday evenings from 6.30 to 7.45. Fee £2.

Solid and Gaseous Fuels. SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3. Course commencing September 24, Tuesday evenings from 6.30 to 7.45. Fee £2.

Nuclear Energy Applied to Electrical Engineering. BRADFORD EDUCATION COMMITTEE, TECHNICAL COLLEGE, Bradford. Course commencing September 26, Thursday evenings from 7 to 9. Fee £1 10s.

General Technology of Petroleum. SIR JOHN CASS COLLEGE, Jewry Street, Aldgate, London, E.C.3. Course commencing September 26, Thursday afternoons at 3.30. Fee £1 10s.